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CONTENTS

Cover: Ear tattooing a criollo calf in Venezuela. (Photo: B. Müller-Haye)

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Using large muscular breeds to improve world beef production

by B. Vissac

The beef consumed throughout the world comes from three main types of enterprises:

1. Dairy herds where females are milked and meat is a by-product of milk production.
2. Single suckler herds (cow-calf operations) where specialized beef breeds (which tend to be small and fat) are used in environments that are favourable to beef cattle raising (i.e. grassland areas with a temperate climate).
3. Single suckler herds where, because of unfavourable conditions of climate, disease, and/or nutrition, local cattle adapted to adverse environments are utilized.

The breeds used in these three situations generally lack the muscular growth potential needed to meet the modern consumer's demand for lean, tender meat. This accounts for the efforts made in the last 20 years to improve beef cattle for meat production, principally by encouraging the use in crossbreeding of breeds with a high muscular growth potential. These are primarily continental European breeds raised in favourable environments and selected according to objectives (work and meat) that give full scope for the manifestation of this trait.

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After an initial over-optimistic phase in which the muscular growth potential of "exotic" breeds generally showed spectacular development in the first generation crosses, there appeared various shortcomings in the fitness components of the crosses (particularly females). The problem of optimum utilization of exotic genetic material with a highly developed musculature was then approached with a view to increasing meat production when starting from an indigenous female foundation stock. What, in this situation, is the best crossing scheme to use? The answer to this question depends on several considerations concerning the genetic material:

1. The relative importance of hybrid vigour and of additive gene effects on the desired trait. This will determine the method of crossing to use, i.e. systematic crosses for the market or creation of new breed types. The first method, in contrast to the second, leads to maximum manifestation of hybrid vigour.

2. The importance of direct effects compared with maternal effects of the genes determining a given trait. In this connexion, the independence (and even antagonism) which seems to appear statistically between breed types for these two kinds of effect can lead to the use of "muscular breeds" to produce calves entirely for slaughter (terminal cross), or from which the females will be used for breeding for only a limited number of reproduction cycles or not at all. This leads us to determine:

(*a*) A paternal value or component of breeds, for one or more traits; this appears when comparing the meat

value of the progeny of bulls of these breeds crossed with a given type of female.

(*b*) A maternal value or component of the same breeds, i.e. that manifested for one or several traits influencing production efficiency when we compare females of these breeds mated with a single breed of bull.

3. The adaptation of the breeds concerned to the production environment and, more specifically, to climatic, health, and nutritional factors comprising that environment. What proportion of genes of local breeds should be kept for adaptation to one or another natural or man-made stress (for example, suckling or artificial feeding) in introducing improved breeds?

The research conducted in France can provide some information on these aspects because:

- Many of the "muscular breeds" are native to France and are widely exploited there; one can therefore compare more uniform and more representative samples of animals from the populations existing in France than from those used in experiments carried out in the new user countries.

- The French breeding environments are fairly representative of the various beef breeding conditions mentioned above, i.e. dairy cattle breeding; beef cattle breeding in favourable environments (areas of central France populated by Charolais and Limousin), or unfavourable environments, i.e. mountainous or subhumid areas of central and southern France where the animals must be specially adapted to prolonged nutritional deficiencies in the summer or winter.

- The remarkable development of artificial insemination in France (70 percent of females inseminated, 50 percent of them belonging to suckler cow herds) affords a useful structure for setting up experimental selection or crossing experiments and, more generally, for cooperation between researchers and livestock breeders' associations in the field of genetic improvement.

Improvement of meat production from the dairy herd

The process of selection for milk production leading to the gradual replacement of less productive breeds, strains or lines by others highly specialized for milk production makes it possible to rapidly increase meat production independently of milk by crossing the lower yielding cows (30 percent on average) with bulls of the beef breeds.

In general we are dealing with small- or medium-sized farms using artificial insemination. First generation crosses principally comprise heifers that are managed intensively, inseminated from a bull of a small beef breed, and probably slaughtered after an early first calving. This establishes a fattening unit of "once-bred" heifers that is partly self-replacing (FAO, 1972). However, when the milk yield is low and the farm large, milking may be given up and cows bred to beef bulls and used for suckler calf production (e.g. in the United Kingdom and Ireland).

In any case, as the aim generally remains a terminal type cross, the tendency will be to choose beef breed males on the basis of their paternal components or values mentioned above, as reflected by the calves' potential for muscular growth.

In line with this approach, the French insemination centres concerned, in liaison with the National Institute for Agricultural Research (INRA), have been developing programmes since 1955 that are designed to create,

Eleventh rib from the carcass of . . .

select and compare beef strains for use in terminal crossing (Centre national de recherches zootechniques, 1972). The strains studied have consisted of:

1. Registered animals (Charolais, Limousin, Blonde d'Aquitaine) of normal type, as distinct from the type with muscular hypertrophy or double-muscling. The percentage of isolation of strains in the registered population varies according to breed, being higher in Blonde d'Aquitaine and Limousin, where the selection schemes

for terminal crossing are tending to lead to completely isolated strains.

2. Breed crosses between registered animals of normal type. The breed combinations are designed to bring together more compact genetic types having higher growth potential (Charolais, Maine-Anjou) with longer bodied and taller breeds (Blonde d'Aquitaine, Limousin) which for a given weight at birth have a lower frequency of calving difficulties.

3. Crosses between animals with muscular hypertrophy. Unlike the two preceding categories, which are selected by the insemination cooperatives, this operation is carried out by INRA on its Carmaux farm which has two herds of female crosses: Charolais × Blonde d'Aquitaine and Maine-Anjou × Limousin or Blonde d'Aquitaine. In this and the preceding case, the schemes tend toward the production of isolated populations. Males of all these strains are first subject to individual within-strain selection and are then simultaneously progeny tested in comparison with a national control lot (Charolais, Limousin or Blonde d'Aquitaine) according to the value of their crossbred progeny out of dairy females; the female base is progressively becoming Friesian. The crossbred calves, initially raised for veal and recorded on the farm, are increasingly being recorded at a testing station, half being slaughtered at 15 months and half at 18 months, thus giving a comparison of strains based on different ages at slaughter (Centre national de recherches zootechniques, 1972).

. . . a double-muscled Charolais bull

Although the initial objectives of bull selection by both performance and progeny tests were designed to improve only the muscular growth potential of the animals or their progeny, other criteria have gradually been introduced into the index:

(*a*) Efficiency of feed utilization (independent of growth rate).

(*b*) Meat quality (some components of which can be detrimentally affected by increase in muscularity).

(*c*) Ease of calving (direct effect). Indices restricting genetic progress in birth weight have been constructed, based on the males used for crossing; moreover, semen distribution can be based on the bull's birth weight index on the one hand, and on the dairy females' ease of calving on the other. If little or nothing is known about the ease of calving, the female population can be classified by age and breed and according to size of pelvic opening or weight, i.e. estimated size for each age and breed class based on a small sample of individuals (Menissier *et al.*, 1975).

In fact, it is becoming increasingly difficult for a single strain to meet all the objectives sought in a terminal cross. These objectives vary widely according to:

(*a*) Calving age and ease of calving of females. Some insemination cooperatives have therefore been involved in the formation of strains known as "maximal" (no limitation on increase in weight at birth) and "optimal" (strict limitation of the increase), the latter being mainly confined to early-calving heifers. Such an approach should be able to provide for the most rational utilization of the pelvic passage which, in the long run and with only a single calf, in the female must constitute a basic limiting factor to beef production.

(*b*) Type of production of crossbreds (especially females), i.e. milk × meat. In this connexion, increased muscular development within strains or between strains is generally accompanied in crosses by a delay in body maturity. Thus the use of double-muscled bulls on

Table 1. **Comparison of French beef breeds, breeding phase** [1]

Trait		Maine-Anjou		Charolais		Limousin	
		Sires [2]	Dams [3]	Sires [2]	Dams [3]	Sires [2]	Dams [3]
Calf weaning rate for first three seasons	%	—	59	—	54	—	64
Very difficult calvings							
at 2 years	%	58	56	40	57	36	21
at 3 years	%	47	43	24	46	17	0
Calf weight at weaning (6 months) for first three seasons	kg	214	219	211	215	207	198
Weight of dam after calving at 4 years	kg	—	624	—	652	—	569
Productivity: weaned calf weight/ dam's metabolic weight		—	1.16	—	1.01	—	1.22

[1] This comparison is based on results of a factorially designed experiment conducted with purebreds and crossbreds at the INRA experimental farm at Galle, Avord 18800, France. — [2] Progeny of sires of this breed in purebreeding and in crossbreeding with the other breeds. — [3] Progeny of dams of this breed in purebreeding and in crossbreeding with the other breeds.

Friesian cows delays by one to two months the age at which the carcass of the crossbred animal shows a given fat percentage. This can be a considerable advantage in the case of crossbred females which under an intensive management system (slaughter at about 14 to 16 months) can thus reach slaughter weight without getting too fat.

On the other hand, females produced by double-muscled bulls will show a reduction in fitness (sexual maturity, ease of calving), so that such bulls are less used in systems involving slaughter of females after an early calving (Bibe *et al.*, 1974).

The field is thus open for competition between beef cattle strains designed for crossing with dairy females by insemination. Comparative data should now be refined according to the type of female being crossed and the type of meat production. To be effective, an analysis of the results will make it increasingly necessary to coordinate experiments because it suggests an easy way of increasing meat production independently of milk in industrialized countries which have mainly dairy cattle bred by artificial insemination.

Improvement of meat production from specialized beef herds

In systems where female progeny are normally kept for breeding, numerous shortcomings of "muscular breeds" in extensive production systems have appeared, particularly in the fitness components. These observations are logical enough, considering the artificial environment in which the animals have sometimes been maintained in small- and medium-sized herds, i.e. calving supervision and assistance, control of heat periods, supplementary feeding of calves (nurse cows), and housing in winter and during the night in summer.

The results of experiments in France and other countries reveal a genetic antagonism between the calves' potential for muscular growth and female fitness components; in the case of traits depending on both the calf's and the dam's genotype (e.g. weight at weaning), this antagonism seems to involve the offspring's growth genes on the one hand and the genes controlling the dam's milk production and maternal behaviour on the other. This conclusion emerges clearly from the comparisons that can be made (*a*) between French breeds of variable size and muscularity raised in specialized beef herds; (*b*) between Charolais strains selected in different countries (the differences in musculature between these strains, e.g. between Brazilian Charolais and United States Charolais specifically selected for terminal crosses, are greater than those found on average between animals of different breeds) and (*c*) between progeny of bulls. Here, the French results confirm those obtained in the United States on the antagonism between the direct and maternal effects determining weight at weaning.

Such observations lead us to seek the best equilibrium in genetic structure, either by selection within breeds or in crossbred populations, or through systematic crossbreeding. The first method will seek to exploit mainly the additive and epistatic effects of genes. The second, which is more difficult to implement, will also involve dominance effects, and above all, complementarity between the calf's and the dam's genes which will depend, in particular, on the order of the introduction of breeds in the crossing schemes.

The search for such equilibria implies an analysis of the genetic variability between and within "muscular breeds" and smaller beef breeds (Hereford, Aberdeen-Angus). The experimental and improvement programmes

Table 2. **Comparison of French beef breeds, fattening phase** [1]

Trait		Maine-Anjou 15 months	Maine-Anjou 18 months	Charolais 15 months	Charolais 18 months	Limousin 15 months	Limousin 18 months
Daily weight gain	*g/day*	1 521	1 348	1 469	1 276	1 399	1 284
Feed consumption index	*feed kg/gain kg*	7.7	8.8	7.5	8.6	7.2	8.2
Final weight	*kg*	593	700	564	676	531	654
True dressing yield	%	67.1	67.3	67.7	67.3	67.7	69.3
Hot carcass weight	*kg*	331	399	316	382	302	386
Body composition (11th rib)							
Meat %	%	67.0	63.8	69.3	66.7	69.6	69.2
Fat %	%	16.4	19.2	14.7	16.7	13.6	15.6
		Francs					
Productivity							
Feeding (cost)		1 170	1 918	1 096	1 775	1 001	1 702
Meat (income)		3 767	4 325	3 716	4 323	3 586	4 535
Profit (income minus cost)		2 597	2 407	2 620	2 548	2 585	2 833

[1] This comparison is based on results of experiments conducted with purebreds and crosses at the INRA experimental farm at Galles, Avord 18800, France. Average values are for paternal and maternal breeds in purebreeding and crossbreeding (average by row and column for a given breed).

undertaken in central France in the areas where specialized beef production predominates have been carried out with precisely this aim.

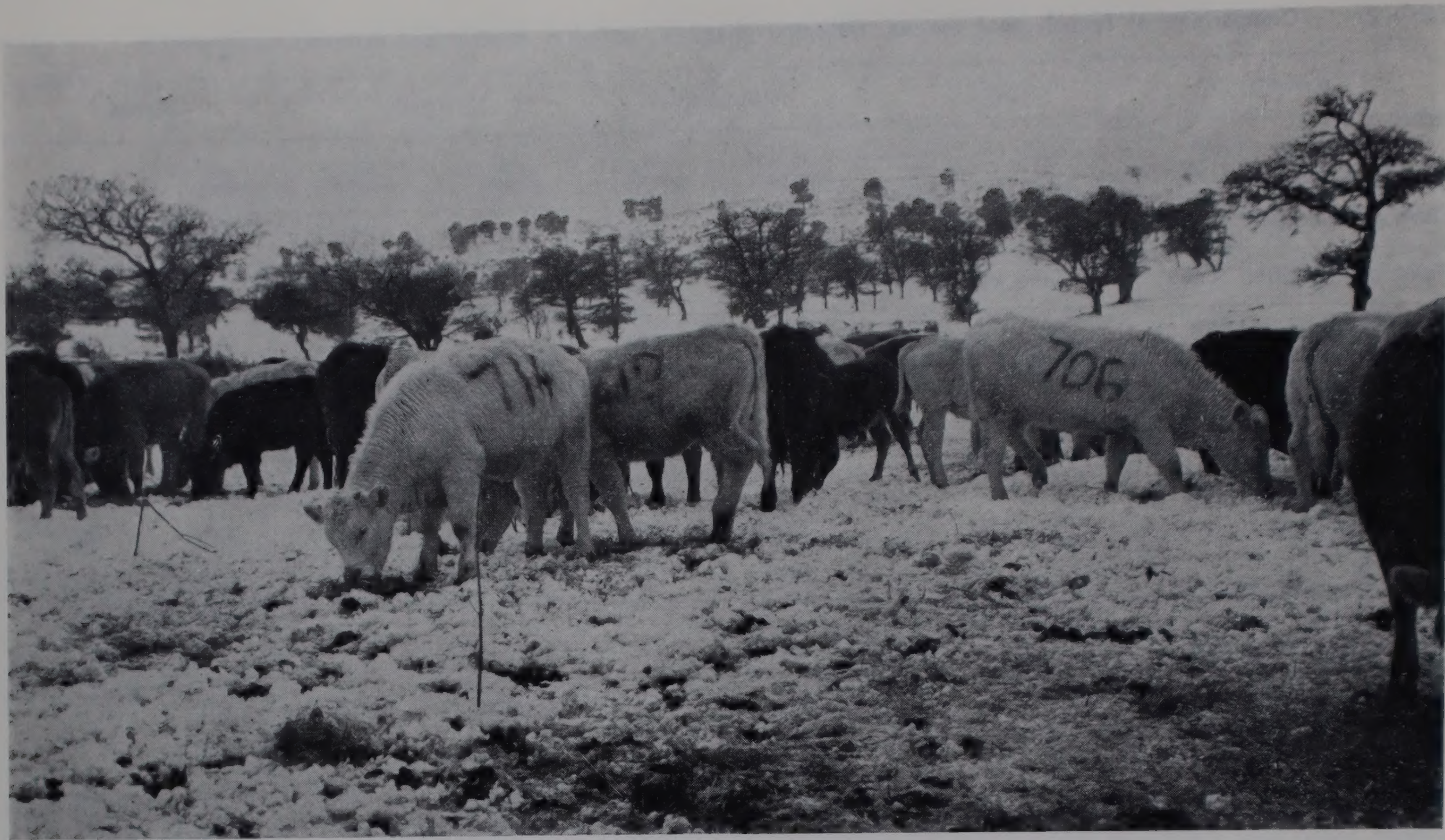
Studies on between-breed variation. A factorial plan of crosses between samples of animals representing the registered populations of the three main French beef breeds (Charolais, Limousin, Maine-Anjou) was set up on the Bourges experimental farm, which also has a purebred Hereford control herd. For practical reasons, the females are zero-grazed. The results of the first four years of operation presented in Tables 1 and 2 can be summarized as follows (Menissier *et al.*, 1974, 1975):

- Under the conditions of this test the Limousin breed presents the most favourable maternal components for measurable productivity traits. It also gives the best results during the fattening phase (paternal and maternal components) when the animals are slaughtered at 18 months. On the other hand, for earlier slaughter (15 months), all three breeds give comparable results.

- Reciprocal crosses between Limousin and Maine-Anjou show excellent complementarity in calving fitness as well as weight at weaning and carcass value (body composition).

- Heifers and young cows of the Charolais and Maine-Anjou breeds in particular show a high frequency of calving difficulties. In this dystocia, the relative importance of paternal and maternal components (size of foetus and pelvic opening) varies according to breed and cross. We might consider decreasing these difficulties through reducing the adult size of breeding females by applying crossing schemes in which the females are divided by age into two groups. Thus, for their second and third calvings cows are mated in a rotational crossing system consisting of alternating small breeds which complement each other for the different components of fitness, including ease of calving; all the female offspring are kept for breeding. Older cows are mated to larger bulls with greater muscular development, and all male and female offspring are slaughtered. Such a system of course eliminates the possibility of female selection, but the generation interval is shortened considerably.

Studies on within-breed variation. Since selection for fitness proved necessary in the case of the "muscular" French breeds, it was essential to find more efficient methods than natural selection, which was considered adequate under extensive conditions (e.g. in North America and Australia) with breeds of British origin. This is the object of selection schemes for bulls of beef breeds used for artificial insemination in France in specialized beef breeding areas (Foulley and Menissier, 1974). The schemes include in particular a station test of female progeny — a comparison of 20 female offspring per bull, from weaning to 30 months, which are fed intensively so that they can be calved down at 2 years. Although this system is a considerable departure from



Sardinian, Modica, Brown Swiss and first-cross cows with Charolais and Piedmont in the experimental beef herd at the Sardinian Zootechnical and Dairy Institute at Foresta di Burgos, Sardinia

more extensive methods adopted in many countries and covers only a short phase of the animal's reproductive life, it was considered *a priori* to be effective for "muscular breeds."

As seen earlier, the basic handicap of their maternal components influences the traits appearing early in the females' life (sexual precocity, ease of first calving). A positive correlation may be presumed between the traits related to the first reproduction cycle and those concerned with later cycles. In this connexion, the greater variation appearing at a young age may provide a better assessment of the genetic variation in the adult female in the same traits (e.g. fertility), even with a small population.

Improvement of meat production from beef herds in adverse environments

The limited world feed supply and the high cost of beef production in fertile areas suited to intensification are leading to increased use of poor grazing areas (arid and mountain zones) and of the by-products of intensive cultivation by beef cattle which, with sheep and goats, are the only animals able to exploit profitably these areas and products. But it is necessary to find the best way of improving these potentials of local female populations adapted to the environments by crossing with males of beef breeds. We must also determine the possible use in such environments of crossbred females (milk × meat) from dairy herds in nearby intensive environments such as irrigated lowland areas associated with arid mountain areas, e.g. in the Mediterranean basin.

The research undertaken in cooperation with the Sardinian Zootechnical and Dairy Institute on hardy breeds of southern France and Sardinia provides useful information on this question in areas characterized by more or less prolonged undernutrition (Bibe *et al.*, 1974; Casú *et al.*, 1975).

When suckling cows are maintained in protected environments in which they are given feed supplements during periods of undernutrition, a two-stage crossing consisting of two successive crosses of local females with meat breed males (Charolais or Blonde) seems to be the optimum solution. Experiments on this were undertaken in southern France with the Aubrac and Gasconne breeds. In the long run this formula is more effective than upgrading the local breed to the meat breed. But when local environmental conditions cannot be changed (as in the Sardinian experiments), only a first generation crossing of local females with beef bulls will make local beef production more profitable. This is partly due to the relatively good maternal fitness of the local breeds that were exploited in the past for milk, meat and draught.

Double-muscled bulls and their female offspring have a reduced fitness and poorer adaptation which often make their use in breeding less effective in adverse environments. This also generally applies to crossbred females, i.e. offspring of dairy cows by beef bulls.

All of the results stress the importance of limiting the introduction of new genetic material in adverse beef

cattle breeding environments. Preliminary studies should be undertaken to set the limits to crossing of local females with males of improved breeds. They should cover a range of environments representing present conditions as well as economically and humanly foreseeable environmental changes made by man to improve health and nutrition. As we have shown, they are likely to lead to solutions requiring the maintenance of a large sample of the local breed.

In more general terms, it is necessary to establish the interaction existing between genetic types of beef cattle and their environments. However, direct analysis of these interactions as traditionally practised (i.e. simultaneous comparison of several genetic types in several environments) requires a much too costly experimental set-up often prepared on too vague a basis. In fact a given environment represents the synthesis of disease, climatic and nutritional stress. It would be advisable to analyse thoroughly the genetic differences existing between beef cattle populations with reference to each basic type of adaptation or stress. There would then be a better understanding of the interactions discovered, and the field of application of the experimental results could be expanded. The initial work done in France and Sardinia with this approach has led to some useful conclusions:

- The higher productivity of local females under the extensive management conditions of Sardinia is related to their apparently greater ability to maintain their body weight and that of their foetus and their milk production during or after a prolonged drought period (Casú *et al.*, 1975).

- The ability of suckler cows of beef and hardy breeds to maintain their body temperature when subjected to a controlled heat stress seems to be related to their musculature.

Such tests could, if necessary, be used to improve the sampling done at present in temperate countries to select breeds and genetic types for use in crossbreeding to improve maternal performance of beef cattle in adverse environments.

Conclusions

Genetic improvement of the potential for muscular growth, which in most countries and situations seems to be regarded as the quickest way of increasing meat production and adapting such production to consumer tastes, presents considerable limitations which must be understood. In fact it is more or less closely associated, depending on the situation, with a lowering of fitness and adaptation traits of both males and females. This observation gives rise to several considerations:

- We will generally be led to seek a balance between growth and adaptation traits, such a balance being determined by the conditions of the natural or artificial environment with which we are dealing.

- Crossing between breeds showing complementary traits (small female × large "muscular" male), which also enables hybrid vigour to be exploited, will become a necessary part of any plan for improving meat production.

- It is therefore becoming increasingly important for the producer to maintain the variability of existing genetic material. This will be achieved mainly by exploring in a more thorough and dynamic way the possibilities of exploiting this material in environments possessing the feeds and breeding types to which it is particularly suited. In this respect, we can only regret the scarcity of our information and the excesses that have led to the wide application of results obtained in special and frequently favourable intensive environments to situations where beef production can often be operated profitably only in marginal areas or on by-products, or in some cases must itself be only a by-product of dairy production.

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Red Danish cattle in the tropics

by Ove Madsen

A survey of exports of Red Danish cattle up to 1964 (Neimann-Sørensen and Ipsen, 1967) shows that most of these animals were exported to eastern European countries, and as a result there are now rather large populations of Red Danish cattle in some of them. Their performance is fairly well described in studies by Dymnicki (1974) in Poland, Loukotoval (1973) in Czechoslovakia and Vankov (1973) in Bulgaria. Genotype-environment interaction between herds in Denmark and eastern Europe is covered by Petersen (1975).

Red Danish cattle have also been exported to several tropical countries, but in most cases little is known about their performance. This is due to lack of adequate production records, and to poor contact between Denmark and the purchasing country after export. In Thailand and India, however, exports were integrated into development programmes for milk production, and as a result reliable records are readily available. It has thus been possible to analyse the performance of purebred and crossbred Red Danish cattle under tropical conditions.

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Purebreds and crossbreds in Thailand

A detailed discussion of the crossbreeding programme in Thailand was given by Madsen and Vinther (1975). The programme was undertaken at the Thai-Danish dairy farm, which is situated 15° north of the equator and 230 m above sea level. The climate is tropical, with daily temperatures ranging from 19°C in the cool season to 38°C in the hot season, and with relative humidities of 65 and 95 percent in the dry and rainy seasons respectively.

When the project was initiated in 1962 no fixed breeding policy had been agreed upon. In the initial phase upgrading to Red Danish cattle was practised, but because of high mortality and disease incidence among purebred and grade cattle, back-crossing to the Sahiwal and Red Sindhi was adopted in the later stages. The foundation stock consisted of native cattle, improved native cattle (mainly white zebu from Burma), Indian milch breeds (Sahiwal and Red Sindhi) and Red Danish cattle.

Data were analysed using the least squares technique, thus correcting for environmental effects. Details of the method of analysis and of feeding and management practices have been provided by Madsen and Vinther (1975). Table 1 shows that mortality was highest among purebred and high-grade Red Danish cattle, followed by Indian milch breeds. It was very low in the F_1 generation, presumably because of heterosis effects. Mortalities were roughly the same among the crossbred groups having 37.5, 62.5 and 75 percent genes from Red Danish cattle.

Part of the grade Red Danish herd, Karnataka State

On the basis of the results, it was concluded that the optimum proportion of genes from Red Danish cattle for the environmental conditions prevailing in this experiment could be up to 75 percent but not more.

As shown in Table 2, the age at first calving was high in the Indian milch breeds, whereas only minor differences were found between the other breeding groups. The calving intervals followed the same pattern as the figures for mortality, being very high for purebred Red Danish cattle, rather high for the Indian milch breeds, low in the F_1 generation, and with only minor differences among the other crossbred groups. The milk and butterfat yields in the first and second lactations increased almost linearly with increasing proportion of genes from Red Danish cattle. It was therefore concluded that the proportion of genes from Red Danish cattle should be as high as possible, but within the limits set by mortality and disease, i.e. about 60 to 80 percent.

First lactation yields were much higher for Red Danish cows imported from Denmark than for those born in Thailand. In the second lactations, however, the yields of imported animals were lower than those for animals born in Thailand. These results will be discussed later.

Purebreds in India

The Indo-Danish project is situated 30 km from Bangalore, 13° north of the equator and 880 m above sea level. The climate is tropical monsoon, with daily temperatures ranging from 10°C in the cool season to 38°C in the hot season, and with relative humidities of 63 and 86 percent in the dry and rainy seasons respectively.

A total of 18 bulls and 223 pregnant heifers were imported. These animals were used for purebreeding at the project farm. Male progeny were sold for breeding purposes to private farmers, but it has not been possible to trace the progeny of these bulls to any great extent. Nevertheless, it was possible to evaluate the performance of female crossbreds within the confines of the extension area of the Indo-Danish project. These results will be discussed in the following section.

Feeding and management at the Indo-Danish project were practised according to Danish standards as far as possible. The data were analysed using the least squares technique, thus correcting for environmental effects. The cows of the Red Danish breed were classified into three groups: cows imported from Denmark, cows born in India out of sires from Denmark (i.e. first-born calves from imported heifers), and

Table 1. **Frequency of abortions, stillbirths and mortality of calves and of replacement heifers in Thailand**

% of Red Danish genes in the calf	Abortions [1]		Stillbirths [1]		Mortality up to 6 months		Mortality from 6 months to calving	
	Number of pregnancies	Frequency	Number of calves born	Frequency	Number of heifer calves	Frequency	Number of six-month-old heifers	Frequency
		%		%		%		%
0	170	4.6	165	6.6	58	15.5	37	5.4
37.50-43.75	1 163	5.4	1 085	5.6	450	9.1	243	10.7
50	923	1.8	886	4.4	477	3.7	442	2.0
62.50-68.75	549	5.0	517	6.0	251	8.8	146	9.6
75	1 835	3.8	1 716	3.8	634	7.4	529	9.1
87.50-93.75	406	5.3	376	3.3	152	9.2	130	20.0
100	290	21.5	222	5.1	96	7.3	93	23.7

SOURCE: Madsen and Vinther, 1975.
[1] Least squares means.

Table 2. **Age at first calving, 305-day yields in the first and second lactations, and calving intervals in Thailand**

% of Red Danish genes	Foundation females	First lactation [1]				Second lactation [1]			Calving interval [1]	
		Number	Age	Milk yield	Fat yield	Number	Milk yield	Fat yield	Number	
			Months	. . . . *Kg*	. . . .		. . . . *Kg*	. . . .		*Days*
0	Indian milch breeds	33	34.8	987	44.65	36	1 000	43.04	188	467
37.50	Native or improved native	90	28.7	1 000	47.28	7	1 193	57.21	85	421
50	Native	129	28.2	1 128	61.94	83	1 411	72.96	276	410
50	Improved native	146	27.3	1 256	66.02	107	1 608	78.70	385	419
50	Indian milch breeds	36	28.0	1 960	87.54	18	2 255	101.60	59	443
75	Native	119	29.0	1 689	79.61	72	1 996	91.57	242	446
75	Improved native	236	28.8	1 875	87.00	156	2 210	99.89	509	441
87.50	Native or improved native	76	29.7	1 928	86.60	53	2 238	97.39	166	464
100	Red Danish born in Thailand	44	30.2	2 305	95.44	17	2 760	114.50	48	525
100	Red Danish born in Denmark	94	29.0	3 445	133.61	51	2 561	106.98	126	480

SOURCE: Madsen and Vinther, 1975.
[1] Least squares means.

cows born in India out of Indian-bred Red Danish sires. Table 3 shows the milk yields, butterfat yields and calving intervals for these three groups of cows.

The difference of 326 kg milk and 11 kg butterfat between cows imported from Denmark and those born in India out of sires from Denmark is partly genetic and partly environmental. Genetic differences are expected because the imported animals were a selected sample of the population from Denmark, whereas very little selection was done among the calves born in India. Environmental differences may be caused by differences in feeding, management and/or climate during rearing.

The difference of 275 kg milk and 15 kg butterfat between cows born in India by sires from Denmark and those by Indian-born sires is a measure of the difference between the two sire populations. It is presumably caused by sires from Denmark being selected on the basis of progeny tests, whereas sires from India were selected on the basis of pedigrees only.

Table 3. **305-day yields, lactation lengths and calving intervals of purebred Red Danish cattle in India**

Breeding group	305-day yield [1]			Lactation length	Calving interval [1]	
	Number	Milk	Fat		Number	
		..... *Kg*	.....	*Days*		*Days*
Born in Denmark, imported before calving	314	4 111	173	425	276	478
Born in India, sire from Denmark	108	3 785	162	391	94	457
Born in India, sire from India	169	3 510	147	392	121	454

[1] Least squares means.

Table 4. **305-day yields, lactation lengths and calving intervals of purebred and crossbred cattle in India**

Breeding group	305-day yield [1]			Lactation length	Calving interval [1]	
	Number	Milk	Fat		Number	
		..... *Kg*	.....	*Days*		*Days*
Red Sindhi	8	1 522	66	329	5	538
Improved local cattle	1 012	2 204	100	347	594	478
Red Danish × improved local cattle	114	2 661	117	405	70	480
Red Danish × Red Sindhi	31	3 180	152	377	21	417
Red Danish × Hallikar	13	2 335	100	405	6	468

[1] Least squares means.

Crossbreds in India

Milk recording began in villages in the Bangalore area in 1967 with the recording of 24 cows. In 1974 a total of 772 cows were milk recorded. Along with the milk recording scheme, an advisory scheme on feeding was operated. Thus cows were fed according to production. During the rainy season many farmers fed green fodder, while during the dry season most farmers fed only straw and concentrates.

Pedigree information was available for some of the cows in the milk recording scheme, making it possible to classify them into breeding groups: Red Sindhi, Red Danish × Red Sindhi, Red Danish × improved local cattle, and Red Danish × Hallikar. However, for most of the cows there was no pedigree information. Since most of them were crossbreds between European and local cattle, they were classified as improved local cattle. Data for all these groups were analysed using the least squares technique, thus correcting for environmental effects.

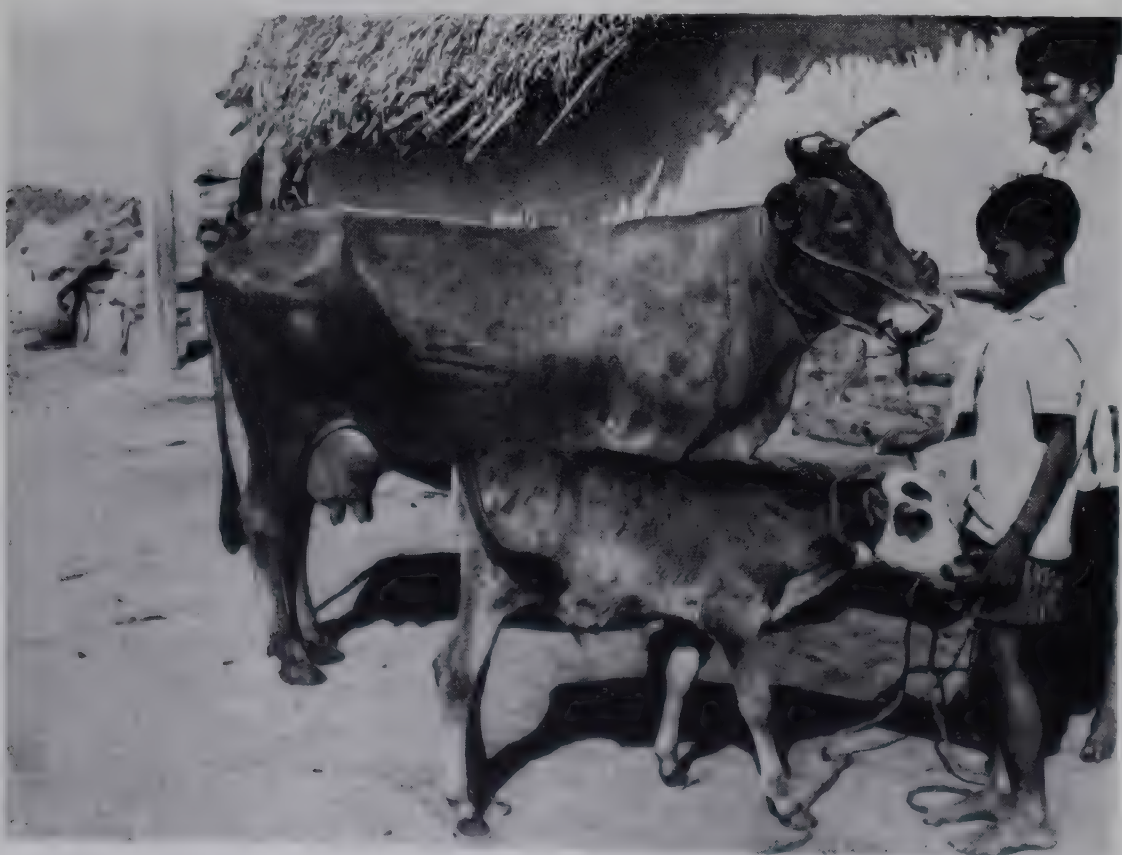
Table 4 shows the 305-day yields of milk and butterfat and the length of calving intervals. The number of observations for the Red Sindhi is small, but the results coincide with those of previous investigations in that the milk and butterfat yields are low and the calving interval is long (Mahadevan, 1966).

It is assumed that the average proportion of *Bos taurus* genes in the group of improved local cattle was around 50. Few of these cattle were first crosses; thus heterosis effects are probably not important. The production records of this breeding group may therefore be considered as an estimator of the performance of cows which have approximately 50 percent *Bos taurus* genes but are unbiased by heterosis effects.

By contrast, the Red Danish × Hallikar and Red Danish × Red Sindhi breeding groups are expected to have their full heterosis effects. Assuming that the producing ability of purebred Red Danish cattle under village conditions is the same as at the Indo-Danish project, the estimated heterosis effects for the F_1 generation (Red Danish × Red Sindhi) are 16 percent for yield of milk, 30 percent for yield of butterfat and 16 percent for calving interval.

Thus crosses between Red Danish and Red Sindhi have performed better than might have been expected had there been no heterosis. This was also observed in crosses between

Below, Red Danish × improved local cattle. Above, Red Danish × Red Sindhi



these two breeds in Thailand. These results indicate that there may be a large specific combining ability between them on crossing.

A comparison of Red Danish × improved local cattle with improved local cattle shows that crossing with Red Danish cattle increased milk yield by some 457 kg and butterfat yield by 17 kg, whereas the calving interval remained virtually unchanged. On the assumption that improved local cattle have 50 percent *Bos taurus* genes, this difference would be a measure of the effect of increasing the proportion of these genes from 50 to 75 percent.

Imported purebreds and purebreds born in the tropics

In the Thailand data there was a decline in production from first to second lactation among imported heifers. The Indian data showed different results, but the increase in yield from first to subsequent lactations was much smaller than that normally observed in temperate countries. In India maximum production occurred in the second lactation, when correction for environmental factors was made.

However, the investigations coincided in regard to the decline in yield from the imported generation to the generations born in a tropical country. As noted earlier, the reasons for this are probably both genetic and environmental. It is not possible to specify how much of the difference is genetic and how much environmental, but it appears that first lactation performance was a biased estimator of the production performance of purebred Red Danish cattle in subsequent generations.

Optimum proportion of Red Danish genes in crossbreds

It may be useful to consider environmental conditions in tropical countries as consisting of climate on the one hand and level of feeding and management on the other. In both Thailand and India feeding and management were at a high level and nearly up to normal Danish standards. However, the climate in Thailand was unfavourable, whereas that in India was not severe. Climate and feeding factors are summarized in Table 5 and compared with those of Denmark. The scoring in the table does not imply that the difference between the climate of Thailand and India is as large as that between India and Denmark; it is made for ease of reference only. The production levels attained by purebred cattle in India are lower than those normally obtained in Denmark, while those of Thailand were even lower than those of India. This pattern follows the scores for climate and feeding/management shown in Table 5.

In both Thailand and India milk and butterfat production was higher for purebred and high-grade Red Danish cattle than for intermediate crossbreds. Similar results were obtained in the United States by crossbreeding the Holstein, Jersey and Brown Swiss with the Brahman and Red Sindhi (Branton, 1966). But previous experience from tropical countries suggests that intermediate crossbreds had higher yields than high-grade animals (Rendel, 1972).

Table 5. **Tentative scoring of climate and feeding/management (3 = Danish standard = most favourable score)**

Country	Climate	Feeding/ management
Denmark	3	3
India	2	2
Thailand	1	2

The most plausible explanation for this apparent discrepancy is that feeding/management was at a higher level in the Thailand, India and United States experiments than in those reviewed by Rendel (1972). If this interpretation is correct, feeding and management exert a greater influence on the productive performance of different genotypes than climate. This hypothesis is supported by the favourable performance of purebred cattle in Israel (Volcani, 1973). It is further supported by the fact that the season of calving had little influence on levels of production in Thailand and India. If climate had had a major influence on production, yields would have been low for cows calving in the hot humid season.

However, the reproductive performance of purebreds and high grades has not been satisfactory in either Thailand or India. The calving intervals were long, and in Thailand the percentage of abortions and mortality was also high. On the basis of the interpretations presented here, it would appear that delayed breeding is a reaction of the cow to relatively high production in an unfavourable climate. A similar phenomen is known to exist in temperate climates: cows are difficult to get in calf immediately after calving, when production is so high that the cow is in negative energy balance.

Conclusions

Milk and butterfat yields have increased almost linearly with the increase in the percentage of genes from Red Danish cattle. This is contrary to several previous experiments with other European breeds, where intermediate crossbreds have had higher production than high grades and purebreds. This apparent discrepancy may be due to the high level of feeding and management in the present experiments.

However, mortality was high among high-grade and purebred Red Danish cattle under unfavourable climatic conditions in Thailand, and reproductive performance was not satisfactory in either Thailand or India.

Yields of imported animals were higher than those of animals born in the tropics. The reasons for this are probably both genetic (little selection in the tropics) and environmental (sub-optimal feeding/management and climate during rearing).

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Trypanotolerant cattle breeds in Zaire

by J. Mortelmans and P. Kageruka

This historical account of the introduction of trypanotolerant cattle breeds into southwestern Zaire highlights the success achieved under good feeding and management conditions on both large and small farms. Current developments in breeding N'Dama cattle in the region and their extension to new land areas are also reviewed.

Cattle were not raised in southwestern Zaire (formerly the Congo Free State) until the early 1880s, when the first animals imported from Angola formed the foundation stock of government stud farms established at Zambi, Kitobola and Dolo to breed draught animals. Later, private stock farms also bred draught bullocks while missions bred cattle both for slaughter and for use as draught animals. At the turn of the century the government farms had about 1 000 animals altogether. By about 1904 the government herds numbered 4 000 head of cattle, and in 1907 there were 70 cattle farms with about 5 000 head (Tobback, 1930). At about the same time, the phenomenon of trypanotolerance was noticed among the humpless cattle of West Africa.

The Dahomey breed

In 1904, 50 head of cattle were bought in Benin (formerly Dahomey) by a Mayombe planter (Drousie, 1919; Flamigni, 1939). This breed of cattle appeared shortly afterwards at the Kangu mission and at the Government Livestock Station at Zambi (Van Damme, 1911). In 1912 Van Damme found these cattle very hardy, well adapted to poor regions and useful as slaughter stock. Importation from Benin continued during the period prior to the First World War; the animals multiplied and spread throughout the Mayombe region and other areas of southwestern Zaire. Drousie (1919) described the Dahomey cattle in this region as being small (90 to 105 cm withers height), but with a relatively high dressing percentage (about 50 percent). Because of the breed's hardiness, he suggested it be spread among the African population, especially because its trypanosome resistance allowed it to be raised in the forest zone where no other bovines could survive.

Flamigni (1948) found these animals very hardy and able to live in hot humid countries on semisavanna and in forests, but noted that they need suitable feed to survive; while they require practically no care, they do need good grazing and water. Since Dahomey cattle like to graze at night, they should not be enclosed in paddocks or pens. However, they should be provided with roofs to protect them from rain. These ani-

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The first N'Dama cattle were brought to southwestern Zaire in the early 1920s

mals like to roam freely in small herds of 3 to 6 head; they live on forest undergrowth and fallow land and seek grazing everywhere, sometimes traversing great distances. According to Flamigni (1948, 1951) the live weight of an adult animal varies from 150 to 200 kg, but may be as much as 200 to 300 kg, while some bulls weigh even more. On the other hand, undernourished, weak individuals may not even reach 120 to 130 kg.

The N'Dama breed

The other trypanotolerant breed in West Africa, the N'Dama or Guinean, was introduced into southwestern Zaire in the early 1920s (Tobback, 1930; Flamigni, 1939; Taminiau, 1960). This too is a small breed that is very hardy and capable of tolerating humid heat. The climate of the region is characterized by two well-marked dry seasons lasting from a month and a half to three to five months, and a mean annual rainfall of 1 000 to 1 400 mm. The mountains are covered by low forests and the hills by low forests, grass or crops, and most streams are bordered by gallery forests (Merckx, 1956).

N'Dama cattle, first introduced by the large livestock enterprises, have spread into the Kwango-Kwilu region to the northeast. Nevertheless, the N'Dama is found primarily on the stock farms of southwestern Zaire, either as a purebred or as a cross-

N'Dama cattle have a latent precocity and reach slaughter weight quickly when raised under good conditions. They have been used to improve the conformation of the Dahomey breed and impart greater hardiness and trypanotolerance to the larger, less resistant breeds of Zaire

bred. On the eve of the Second World War three major stock farms were located in this region: the Kisantu mission with 9 700 head of cattle, the Compagnie des produits et frigorifères du Congo (Isle of Mateba) possessing about 7 000 animals, and the Compagnie Jules Van Lancker at Kolo with some 3 100 head. Six other companies had over 500 head of cattle each and there were 15 smaller farms (Tobback, 1940). By the end of the war, the three major stockraisers owned respectively 9 770, 8 464 and 9 598 head of cattle (Tobback, 1946).

N'Dama cattle have been used to improve the conformation of the Dahomey breed while preserving its hardiness and trypanotolerance, and to impart greater hardiness and trypanotolerance to the larger, heavier and less resistant breeds of southwestern Zaire (e.g. the Angolain, Mateba and zebu).

However, the resistance of zebu crossbreds has been found inadequate, and since 1946 efforts have been directed toward upgrading them to N'Dama (Tobler, 1961). For these purebred cattle to prosper, it was necessary to give them the right environment, i.e. improved pastures with careful control of brush fires, soundly organized use of the range or pastures and watering points, regular surveillance of stock management, and veterinary care. Several writers stress that it is necessary to maintain high standards of feeding and management if the best results from these animals are to be obtained (Renier, 1953; Gretillat, 1953; Druet, 1958; Gillain, 1958; Micknevicius, 1959). They also recommend the N'Dama breed for the stocking of the Kwango-Kwilu region and base their recommendations on very encouraging results observed on various farms in the region.

The performance of N'Dama cattle under prevailing conditions in southwestern Zaire has proved excellent, especially in view of their tolerance to trypanosomes in this tsetse fly-infested region. Taminiau (1960) quotes the following average weights recorded at the Mvuazi station: calves

at birth, 19 to 25 kg; one-year-old heifers, 127 kg; three-year-old cows, 241 kg; four-year-old cows, 281 kg; adult cows, 290 kg; five-year-old bulls, 430 kg; six-year-old bulls, 456 kg. The slaughterhouse dressing percentage averaged 54 percent (maximum 58 percent and minimum 52 percent). At Gimbi in the trypanosomiasis belt, the average dressing percentage is 50.8 percent. At Gimbi, Flamigni (1959) records live weights of 300 to 325 kg for cows and about 400 kg for five- to six-year-old bulls. Tobler (1961) records for the Kolo stock farm a weight of 280 kg for three-year-old steers, 335 kg for four-year-olds, 345 to 375 kg for five-year-olds, and 450 to 550 kg for six-year-old bulls. For the same categories in Guinea he quotes 177 kg, 220 kg, 248 to 310 kg and 300 kg respectively from statistics provided by the Ministry of Agriculture of Guinea. In Guinea (their country of origin), the animals attain slaughter weight at 5 to 7 years of age. Tobler was able to slaughter his cattle at the age of 4 years, by which time the animals had reached a greater slaughter weight than in Guinea. Tobler concludes that the N'Dama breed possesses a latent precocity. These animals reach slaughter weight more quickly when raised under good conditions. Selective breeding, good management and above all a satisfactory and reliable source of feed are the key to early maturity.

Good conditions have a favourable influence on trypanotolerance in both the Dahomey and N'Dama breeds. Well-fed animals show a high resistance to trypanosome infections. Their growth curve is not affected by the infection, and the parasites as a rule quickly disappear from the peripheral bloodstream. It has been observed that even calves a few weeks old from healthy cows barely suffer from attacks of *Trypanosoma congolense*.

Current situation

A recent visit to southwestern Zaire has convinced us of the success obtained by a large livestock enterprise which has introduced N'Dama cattle into this region. Starting with 50 N'Dama heifers and two N'Dama bulls in 1927, the enterprise had expanded to 25 000 head by 1950 and stabilized at that level, with some 6 000 head being available for sale annually. Performance at this enterprise shows a 58 percent dressed weight for slaughter stock, an 80 percent annual calving rate, and approximately 100 percent fertility in the breeding units.

Success obtained in southwestern Zaire has led to the extension of the N'Dama breed into Bandundu Province, where enormous land areas are available for the establishment of new pastures. A total of 950 heifers were transferred to Mushie in 1965-68 (400 in 1965, 350 in 1966, 100 in 1967 and 100 in 1968). At the end of 1974 there were 11 000 head. Mortality averaged 1.5 percent. The N'Dama cattle in Mushie are purebred; it is one of the few herds where no crossbreeding has been attempted.

Summary

The introduction of trypanotolerant breeds into southwestern Zaire has succeeded extremely well. The Dahomey breed, smaller than the N'Dama, is more readily raised in small family herds, while the N'Dama is excellent because of its precocity and high dressing percentage when raised on medium- or large-scale stock farms, as has been the practice in the region for nearly 50 years. In 1960, on the eve of the country's independence, there were more than 120 000 head of cattle in this area, of which more than 100 000 head were on rather large stock farms (16 with over 1 000 head of cattle, 27 with from 200 to 1 000 head of cattle and 107 farms with less than 200 head). Most of the stock on these farms were N'Damas or N'Dama crossbreds. Since then, the herds have continued to multiply and prosper in this region, to the great satisfaction of the stockraisers, the veterinary authorities, commercial firms and government circles.

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Beef cattle production practices in the lowland American tropics

by N.S. Raun

The ecosystems and socio-economic environments in the tropical lowland regions of Latin America vary greatly. Ecosystems may include new fertile soils and old infertile ones, desert regions and areas with an average annual rainfall as high as 10 000 mm, open savannas and dense rain forests, and level as well as hilly topography. Socio-economic environments are influenced by the unique cultural and economic characteristics of a given area, and by the ecosystem.

This article is concerned with basic production practices that should be considered in the development of beef cattle production systems for savanna regions in the lowland tropics of Latin America. Usage and adaptation of individual and combined inputs should be determined by the particular conditions of a given production situation. Consideration is given to technical inputs for production systems using grasslands in areas that are not suitable for crop production, and to the immediate utilization of potentially arable lands for grazing until the necessary infrastructure for crop farming can be developed.

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Land use

In 1972 beef cattle in Latin America and the Caribbean were estimated to number 247 million (FAO, 1973), 150

(Left) Early weaning can often improve rebreeding of cows that are on a low plane of nutrition

million of which were in tropical lowland regions, half being in the infertile savanna areas and the other half in the more fertile soil areas.

Allic soils predominate in the infertile savanna areas. These soils are mainly the red-yellow latosols, or oxisols and utisols. They are highly weathered, quite acid (pH 4.5-5.0), highly aluminium saturated, and very low in bases (Ca, Mg, K) and phosphorus. The allic soil savanna lands comprise a land area of 300 million hectares and have potential for increased productivity. Since most of these lands cannot support sustained crop production without sizable fertilizer inputs, grazing by ruminants appears to be the only feasible method of utilization in the foreseeable future.

The fertile soil grassland regions include approximately 370 million ha, of which part is now grassland and part is forested land that could be cleared and developed as grassland.

Animal productivity

Animal productivity is low in the lowland tropics of the Americas. Most cows calve once every two years, giving a calving rate of approximately 40 to 50 percent. Slaughter animals are marketed at 3 to 5 years of age, when they weigh 350 to 450 kg. This results in extraction rates of approximately 13 percent, with an annual production of carcass beef from the total beef herd of only 25 kg per head (FAO, 1973). This compares with 36 kg in Argentina and 49 kg in Australia, where only pasture-based production systems are used. In the United States, however, where forages provide approximately 73 percent of the total feed units and 23 percent is derived from grain, the production of carcass beef per animal is 80 kg (Feedstuffs, 1975).

Productivity per hectare is also low. Combining all types of land used for grazing (approximately 670 million ha), the stocking rate averages 4.5 ha per animal, and carcass beef production is only 5.1 per ha per year.

The International Centre of Tropical Agriculture (CIAT) recently conducted two surveys in the Colombian llanos, a region comprising open savannas with infertile allic soils, to determine production levels and identify restraints. In the first survey on 40 small- to medium-sized farms that had received breeding females on contract, calving rates ranged from 15 to 81 percent, with 30 percent of the farms having rates above 60 percent (Stonaker *et al.*, 1975b). In the second survey conducted on larger farms, calving rates varied from 29 to 76 percent, calf mortality from 0 to 60 percent and adult mortality from 0 to 6 percent (Centro Internacional de Agricultura Tropical, 1975).

In a survey conducted on the north coast of Colombia, a generally fertile soil area, mean production levels were higher than in the llanos. This reflects a higher plane of nutrition attained as a consequence of a higher soil fertility supporting growth of more nutritious pasture forage. Preliminary information from another survey now in progress on the north coast substantiates these observations (R. Schellenberg, personal communication).

Productivity can be markedly increased through the adaptation and application of known technology. In the Colombian Agricultural Institute (ICA)/CIAT collaborative herd systems experiment in the llanos, acceptable production levels are being obtained from grade zebu cattle that graze native grass pastures and receive mineral supplementation under improved herd management practices (Centro Internacional de Agricultura Tropical, 1975). Calving rates have increased from 49 to 71 percent, and where molasses grass (*Melinis minutiflora*) pastures are used in the rainy season, somewhat higher calving rates (78 percent) have been obtained. Another innovation, early weaning, has increased calving rates to as high as 90 percent.

At the ICA Turipana station in the fertile Sinu river valley on the north coast of Colombia, calving rates of 86 percent have been achieved (Instituto Colombiano Agropecuario, 1972). Even higher production levels (with calving rates as high as 91 percent) have been obtained at the Pichilingue station of the National Agricultural and Livestock Research Institute (Instituto Nacional de Investigaciones Agropecuarias, 1974).

Production constraints

Although acceptable levels of productivity can often be achieved through the application and adaptation of available technology, there are nutritional, disease and germ plasm constraints on achieving the production potential of the feed-animal continuum.

Inadequate nutrient intake from grazed forages, particularly during the dry season, is a principal constraint on the general attainment of high levels of productivity. The severity of this constraint varies with the distribution and amount of rainfall and tends to be accentuated in the low fertility areas.

Disease and parasitism also limit productivity. Most disease agents have been identified, and available basic technology makes it possible to develop and implement effective, economic disease control programmes. However, there are some major technological gaps. The currently used foot-and-mouth disease vaccine confers immunity for only four to five months; it is in fact a deterrent to effective control and is costly to the producer. Tick control methods are inefficient and costly.

Genetic potential places an ultimate limit on productivity. In many instances animals are not producing up to the potential of the current feed-management continuum. Genetic potential will become increasingly limiting as other constraints are removed and as higher production levels are sought.

Production practices for the lowland tropics

On the basis of past experience, the following practices may be recommended as being generally suitable for application throughout the lowland tropics. These include herd and pasture management practices, establishment of improved pastures, mineral and protein supplementation and beef/milk production. Specific recommendations relating to infertile and fertile soil areas will be considered later. Herd health is not considered, as ample information is available elsewhere.

Herd management practices. Only bulls that have shown good growth and fertility should be used for breeding. One bull will be required for every 20 to 30 cows. The bulls should be used alternately and rested for periods of two to four weeks. A high plane of nutrition on pasture is essential to maintain the bulls in good breeding condition.

Non-breeders and old cows should be rigorously culled because the direct costs involved in maintaining them will generally exceed the value of the limited number of calves produced.

Seasonal breeding facilitates the programming of breeding and calving at the most propitious times of the year, simplifies management and reduces labour costs. However, continuous breeding should be used where management skills and information are insufficient. It is also advantageous in dual-purpose herds where cows with nursing calves are milked throughout the year.

Significant improvements in productivity of *Bos indicus* and *Bos taurus* cattle can be achieved through selection (Plasse, 1975). Crossbreeding should be considered where the management system is sufficiently advanced to allow implementation of such a programme; heterosis levels may be expected to be higher than those reported in temperate climates (Stonaker, 1975; Plasse *et al.*, 1974).

Although calves are generally weaned at about 9 months of age, there is considerable evidence that they can be weaned at 6 to 7 months without serious impairment of growth. Also, this will often result in a marked improvement in rebreeding of the cow, as it will stop the nutrient drain for lactation, particularly for cows that are on a deficient plane of nutrition. However, the nutrition of the calf becomes more critical if weaning age is further decreased. As far as possible, high quality pastures/forages should be provided to meet nutrient requirements, thus minimizing or eliminating the need to provide concentrates (Centro Internacional de Agricultura Tropical, 1975; Gomez *et al.*, 1975).

Pasture management. Pastures should be seasonally grazed in order to take advantage of their maximum production potential. High-lying well-drained areas should be preferentially grazed in the rainy season when soil moisture is adequate to support plant growth, and the low-lying high water table areas should be grazed in the dry season.

Invasion of weeds is generally a consequence of incorrect range management or unsuitable pasture species, and should be treated accordingly. Routine use of chemicals should generally be limited to troublesome weeds that are difficult to control and/or eradicate through management and cultural practices (Doll, 1975).

A relationship between stocking rate and efficient utilization of forage that does not result in deterioration of the pasture is often delicate and highly location-specific. Perhaps an extreme example is the replacement of a less desirable species (*Trachypogon vestitus*) by a more desirable species (*Axonopus compressus*) as stocking rate increases (Paladines, 1974).

Under extensive management conditions where pasture forage production exceeds consumption, periodic burning can be an important management tool (Paladines, 1974). Burning toward the end of the rainy season helps to provide higher quality pasture going into the dry season. However, burning should not be used under conditions where pasture forage is limiting, nor should it be used in improved pastures, particularly legume-grass associations.

Improved pastures. Practically every beef cattle enterprise — whether small or large, intensive or extensive, in fertile or infertile soil areas — should have a programme for the establishment of improved pastures. The extent of improved pasture will generally be determined by the nutrient requirements for the critical phases of the production cycle, i.e. breeding, weaning and fattening. Improved pastures will assume greater importance as grazing land becomes limiting, as higher production levels are sought, and as land use becomes intensive.

Many adapted grass species that will withstand grazing can be used over a wide range of situations for the establishment of improved pastures. Some, like pangola (*Digitaria decumbens*), para (*Brachiaria mutica*), star grass (*Cynodon nlemfuensis*) and guinea grass (*Panicum maximum*), are suitable for the more fertile areas. Others, like molasses grass (*Melinis minutiflora*), *Brachiaria decumbens*, *Hyparrhenia rufa*, *Paspalum plicatulum* and tanner grass (*Brachiaria rugulosa*), are suited to infertile soil areas where there is little or no application of fertilizer.

Forage legumes included in grass swards offer the possibility of increasing productivity, particularly in the dry season, because of their high protein content, drought resistance and capacity to fix nitrogen in the soil in association with soil rhizobia. In some areas native legumes abound in association with grasses. But very few tropical forage legume varieties are available for commercial use. However, experimental evidence from the ICA/CIAT experiments indicates that liveweight gains of growing-fattening cattle on *Stylosanthes guyanensis*-grass associations in the llanos can be as high as 150 to 250 kg per ha per year as compared with 60 to 100 kg on improved grass pastures and 10 to 20 kg on native grass pastures (Centro Internacional de Agricultura Tro-

Growth rate can be markedly increased by crossing the adapted Bos taurus **San Martinero breed with the zebu**

pical, 1974). More important still, cattle grazing stylo-grass pastures during the dry season registered weight gains of as high as 40 kg, whereas cattle on improved and native grass pastures suffered weight losses of up to 50 kg. Exploitation of potential depends on identifying species and varieties that are superior to native grasses and will withstand grazing (Raun, 1975).

Mineral supplementation. While the formulation of optimized mineral supplements will be area-specific, it is possible to make general recommendations which could be adapted to local situations. A mineral supplement based on a good phosphorus source, fortified with the trace minerals that are deficient in pasture forage and including only enough salt to ensure palatability, should generally be routinely provided on an *ad libitum* basis, particularly in infertile soil areas. Many pasture species are deficient in phosphorus, especially those grown on low-fertility soils. Although information on trace mineral content of pasture forages is limited, it is generally advisable to fortify the mineral supplement with cobalt, iodine, and copper (Fick *et al.*, 1976). The amounts required are small and cost little. Other trace minerals, i.e. zinc, iron and manganese, will generally not be required.

Protein supplementation. In situations where the dry season is severe and long, it may be advisable to provide a protein supplement to prevent undue weight losses, long calving intervals and delayed marketing of feeder cattle. However, compensatory gain in the rainy season must be considered in evaluating the economics of supplementation.

But where the dry season is less severe and of shorter duration, protein supplementation will often not be economic. In the ICA/CIAT herd systems experiment in the Colombian llanos, supplementation of cows with 80 g urea, 500 g molasses and 4 g sulphur per head per day during the last three months of a four-month dry season reduced weight losses but did not improve calving rate during the first two years of experimentation (Centro Internacional de Agricultura Tropical, 1975). However, possible residual effects in the longer term are as yet undetermined. Dry season supplementation of zebu steers likewise had a limited effect on annual weight gains; although supplemented animals weighed more than non-supplemented animals at the end of the dry season, the latter recovered 50 to 71 percent of this weight difference owing to higher weight gains during the subsequent rainy season (Centro Internacional de Agricultura Tropical, 1974, 1975).

Beef/milk production. Many so-called beef cattle herds are used for both beef and milk production. A recent evaluation of the Colombian livestock industry indicates that 46 percent of the milk that enters commercial channels comes from beef cattle herds, most of which are located in tropical climates (Ministerio de Agricultura, 1974). The milk produced represents a principal source of income, particularly where the livestock industry is more developed and where there is a demand for milk in the urban centres. An example is the north coast of Colombia, where Rivas (1974) found that on farms of up to 200 ha, sales of milk accounted for 33 percent of total income. The corresponding figures for farms of 200 to 500 ha and over 500 ha were 30 percent and 13 percent respectively. This is especially significant when one considers that milk production averaged only 2.5 litres per cow per day in the dry season and 3.1 litres in the rainy season.

The usual practice in beef/milk herds is to separate the calves from the cows in the evening, milk the cows in the morning, leave some milk for the calf, and allow the calf to be with the cow during the day. Continuous rather than seasonal breeding is generally used in these beef/milk systems.

Particular attention should be given to the dry season feeding of the cow and to the nutrition of the calf. Provision for nutritious dry season pastures is crucial, e.g. grass-legume associations. Browse legumes such as *Leucaena leucocephala* might be considered (Hutton, 1974). Fresh chopped sugarcane might serve as an effective energy supplement (Preston, 1974). Conservation of forage produced during the rainy season as hay or silage and other methods of supplementation might also be possible approaches to resolving dry season nutrient deficiencies.

Once a day milking of beef cows is a common practice in the lowland American tropics

Infertile soil areas

The unique problems of beef cattle production in infertile soil areas arise from the low nutritive value of grazed forages, which is principally a consequence of low soil fertility. These problems are accentuated in the dry season. The most serious consequences are an increase in calving intervals and an increase in market age of the animals. In the short term, the remedy lies in improved herd and pasture management practices combined with mineral supplementation, and in the establishment of improved pastures needed to offset inadequacies in nutrient intake during critical phases of the production cycle (Stonaker *et al.*, 1975a).

Mineral supplementation is especially critical in the low-fertility allic soil regions. The phosphorus content of grass species in the llanos, for instance, ranges from 0.07 to 0.09 percent (Centro Internacional de Agricultura Tropical, 1973). Even the tropical legumes that are adapted to these allic soils are often deficient in phosphorus; the phosphorus content of *Stylosanthes guyanensis* is approximately 0.13 percent, which is marginal or below that required for satisfactory growth and reproduction (Centro Internacional de Agricultura Tropical, 1973). In the ICA/CIAT herd systems experiment in the Colombian llanos, mineral supplementation of grade zebu cattle grazing native pastures has increased the annual calving rate from 49 to 71 percent during the initial two-year period (Centro Internacional de Agricultura Tropical, 1975). In addition, mineral supplementation has increased growth rate and significantly reduced abortions, bone fractures, age at first calving and the period to slaughter.

In the long term, with more intensive land use increased attention must be given to the expanded establishment of improved pastures with higher carrying capacities and higher nutritive value.

Fertile soil areas

The greater agricultural development, increased competition for land use, expanded market possibilities and greater production potential of the fertile soil areas call for more intensive production systems and practices. Particular attention should be given to the selection of pasture species that are not only nutritious and high-yielding, but can also withstand grazing on a continuing basis and be competitive with weeds. The greater frequency of milking cows in beef cattle herds in the fertile soil areas and the higher incidence of disease and parasitism associated with increased concentrations of cattle also require improved managerial and preventive medicine programmes.

Summary

There are about 250 million head of beef cattle in Latin America and the Caribbean, of which approximately 150 million are estimated to be located in the lowland tropical areas and are equally divided between the infertile savanna areas and the more fertile soil areas.

Productivity per animal and per hectare is low in the tropical regions of Latin America. The annual production of carcass beef is only 25 kg per head. It is estimated that calving rates are 40 to 50 percent, marketing age 3 to 5 years, and over-all stocking rate 4 to 5 ha per animal, resulting in a carcass beef production of only 5.1 kg per hectare per year.

The primary cause of low productivity is inadequate nutrient intake from grazed forages, particularly during the dry season. The effects of disease, parasitism and genetic potential are generally secondary to inadequate nutrition.

Despite these constraints, the application of available technology can result in significant improvements in productivity and can support the development of economically viable beef cattle-based farming units. This would involve the application of improved herd and pasture management practices. Herd management practices include selection, husbandry and health programmes. Pasture management includes seasonal use of pastures and the establishment of improved pastures when necessary to provide an adequate nutrient intake during the critical phases of the production cycle which cannot be provided by existing pastures. The critical production phases include breeding season, weaning of calves and fattening of animals to be slaughtered.

Particular attention should be given to the management and nutrition required for the dual production of beef and milk in traditional beef cattle herds. A significant proportion of the milk that enters commercial channels is produced by these herds.

The unique problems of beef cattle production in infertile soil areas arise from the low nutritive value of grazed forages. In addition to improvements that can be obtained through better herd and pasture management practices, attention should be given to the establishment of improved pastures in order to provide an adequate nutrient intake during the critical phases of the production cycle.

More intensive beef cattle production systems prevail in areas where soils are more fertile, and this pattern will become more accentuated as agricultural development proceeds, competition for land use increases, and demand for animal products becomes greater.

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Crossbreeding shee
in a Mediterr

by Michael Welham

The sheep in the countries bordering the Mediterranean number about 122 million (Mason, 1967) and vary from the super fine-woolled Merino of Estremadura in Spain to the coarse-woolled Greek Zackel or the fat-tailed desert-adapted sheep of the Near East. Many are triple-purpose breeds unspecialized for any one type of production. Hardiness, the ability to withstand periods of adverse conditions (i.e. sub-maintenance feeding, heat, drought, disease or poor management) and low production appear to be their most important common features. Exceptions are the Chios (or Sakis) breed noted for prolificity and milk yield, and the Sardinian breed, noted for milk production.

In many areas along the northern Mediterranean ewes are milked after lambs are weaned. This may be at 4 to 6 weeks of age in cheese-making areas. Examples are the Lacaune breed in southern France with lambs of 14 kg live weight, and the Langhe of the Piedmont region in Italy (15 to 20 kg). The importance of milk is underscored by the fact that in many of these areas one twin is killed at birth to raise milk sales.

Where the emphasis in production is on meat and wool, ewes may be milked virtually to dry them off, or for short periods after weaning. This occurs with the Merino in Spain when an Easter lamb of 23 kg is sold, or in Turkey where yields of 30 to 35 litres are secured after weaning. The Arab breeds of northern Africa are mainly exploited for meat, with heavier lambs for mutton production taking priority, although milking, particularly in northern Tunisia, is practised for cheese, butter or cooking fat production.

In the northern African countries shepherds wander with their flocks through the countryside, returning to the village or encampment at night. The main advantage of this system is that it facilitates the efficient use of cheap land resources; however, it is a hard life with low recompense for the shepherd. In the more advanced Mediterranean countries attitudes are changing and toleration of such a life is diminishing. Spain has 17 million sheep, more than any other Mediterranean country except Turkey, and an expanding industrial economy competing with agriculture possibly indicates what may happen in other areas which are so far less advanced. Sheep flocks, particularly milk flocks, are declining as labour becomes more difficult to obtain, leaving only the more profitable units and family flocks. At one time or another every country of the area has attempted to improve its own breeds by selection and importation of genetically superior stock. Such programmes have often been short-lived as a result of infertility or poor adaptability of imported breeds. In many cases the genetic potential of purebreds or crossbreds has not been realized by improved feed conditions, or else disease has

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or milk and meat
an environment

Malpica milk sheep

viped out the imported stock. In some instances one aspect of production has been improved at the expense of others of greater economic importance because targets were badly chosen.

This article attempts to show why and how a planned programme of genetic, feed, health and management improvement implemented by a Spanish sheep-breeding company on its dairy and meat farms brought an over-all increase in returns from meat and milk production.

Sheep have been raised on the Malpica estates for centuries. When the present owner, the Duke of Arión, took over the estates in 1955, he continued sheep production with the Talavera (*Talaverana*) breed, originally a Mancha × Merino cross. He began to improve milk and meat production by crossing Talavera ewes with Mancha (*Manchega*) rams, a breed originating in the La Mancha region which is an "entrefino" type, i.e. with wool intermediate in fineness between the Merino and the coarse-woolled Churro. However, by 1970 it became apparent that rising costs could not be met by continuing with the existing system of sheep farming. The gains made by using the Mancha rams were insufficient and too slow to combat these costs. Hence it was decided that the approach to sheep farming would change radically. Increases in efficiency began with the importation of Awassi milk rams and Cadzow Finns with a genetic superiority for production that enabled their F_1 daughters to support a more capital-intensive system. Some of the major economic improvements resulting from this new approach have been a 300 percent increase in production and a 50 percent reduction in land area utilized by sheep. In 1970 less than 10 000 litres of milk were sold per man employed. In 1975 this figure was over 30 000 litres, and by 1977 an output of 60 000 litres per man employed should be achieved. There have been similar increases in efficiency in the meat flocks, where lamb sales have increased by 350 percent per shepherd.

The dairy sheep farms of Cría Ovina de Malpica, S.A. (the Malpica Sheep Breeding Company Ltd.) are based around Malpica-Tajo near Toledo, some 106 km southwest of Madrid. The farm land totals 1 300 ha, lying between 400 and 540 m above sea level. The climate is continental, with cold winters (although the minimum is rarely lower than 1°C) and hot summers (up to 42°C). Rainfall is irregular during the winter months, with no summer rainfall. Snow is rare.

When taken in hand by the Duke of Arión, most of the land was low scrub with *Ilex* species or olive groves. Since then the scrub and olive have been cleared, and all the land can be irrigated with a fixed mains and movable pipe system.

The ewes and young stock have a bulk ration based on 80 ha irrigated mixed pastures (*Lolium perenne, L. multiflorum, Festuca pratensis, Dactylis glomerata, Trifolium repens* varieties), 60 ha irrigated forage cropping

which is sown to rye in the autumn for spring silage and then to forage maize or hybrid sorghum in the spring for late summer or autumn ensiling, and 120 ha subterranean clover, mainly Mt. Barker and Dwalganup varieties. In addition, wheat, barley and sorghum grain stubble, soybean residues and sugar-beet tops are utilized by dry sheep.

The original sheep stock on the farm consisted of 500 Talaveras. In 1966 a further 3 000 Talaveras and Manchas were purchased from farms in La Mancha, Albacete and surrounding districts. Mancha rams were used until 1971, when the Israeli Awassi was introduced.

The meat flock is based in the province of Cáceres at Madrigalejo, 300 km southwest of Madrid. This farm is situated along the northern side of the Ruecas river, which has an irregular flow and dries out in late summer. Of the farm's 770 ha, irrigated pastures and forage cropping occupy 100 ha. The remainder is under dryland farming, with 525 ha subterranean clover and 75 ha of oats for feed and straw. Summer temperatures are higher than in Toledo and spring growth earlier, permitting grazing by late February, compared to mid-March in Toledo. The original stock on the farm consisted of 800 Merinos. Since 1973 these are being replaced by quarter-Finns produced by breeding the Cadzow Improver (derived from Finnish Landrace, Dorset Horn and Ile-de-France) to Manchas and Merinos.

Milk programme

The Israeli Awassi was chosen as the basic milk yield improver because, apart from high yields, it is an extremely hardy animal suitable for large flock management. In 1971, 150 ewes were imported. The flock now numbers 480 ewes and ewe lambs. A further import was due before the end of 1975. Adaptation to Spanish conditions has not been a problem, as shown by mortality and production figures. Of the original 150 ewes, 103 were still in production in October 1975, 22 had been sold because of their low production following an outbreak of mastitis, and the remaining 25 died, giving an annual mortality rate of 4 percent. Yields from first lambings averaged 348 kg milk in 232 days, and from second lambings 410 kg in 264 days. The over-all average, including lambings by ewes 12 to 13 months of age, was 356 kg in 234 days.

Fifty rams were imported in 1971 and a further 130 in 1974. These, plus selected Spanish-born rams, have been used for the crossbreeding programme and for sale. The Company has produced 15 000 first crosses, mainly with Talaveras and Manchas, and estimates that a further 25 000 have been produced from Churros and from Castilians (*Castellanos*), an "entrefino" breed of Castille that is similar to the Mancha breed but is smaller and has a lower milk yield. Besides direct sales, the Company also operates an integration programme, sending out rams to other breeders and buying back 90 percent of the ewe lambs.

Under large flock management the crossbred ewes recorded have given 180 litres in 170 days in the first lactation and 210 litres in 200 days in the second and third lactations when lambing once a year. The practice of three lambings in two years with the higher-yielding crossbreds has been discontinued, but the system is still used with Mancha ewes, of which 84 percent successfully lamb three times every two years. The crossbred yields are substantially higher than the 80 to 95 litres obtained from the basic Mancha stock on the farm.

Parallel to the breeding programme, stringent health, feed, management and husbandry programmes have been implemented. An example is the irrigated pasture, which accounts for increases of about 20 to 25 percent in milk sales. Virtual eradication of losses due to brucellosis and contagious agalactia has been a further boost to yield. All ewes are now machine-milked through two carousels and two pit machines.

The Company now has 6 000 milk ewes and has nearly reached the carrying capacity of the farms for a balanced cereals/sheep system; further production will have to come from higher yields. The lambs resulting from the milk flocks either go to the Company's feedlot or are sold as milk lambs of 12 to 15 kg. Much of the capacity of the 9 000-place feedlot is empty at present as milk lamb prices are 140 to 156 pesetas per kg live weight and fattened lambs of 30 to 32 kg will sell at 105 pesetas per kg live weight.

All Awassi cross male lambs are fattened for slaughter and give a better growth rate than pure Talavera or Mancha lambs (1.8 kg per week compared with 1.5 kg). The Talaveras and Manchas also show a check at 28 to 29 kg, whereas the Awassi cross will grow well to 32 kg. Crosses with Churro ewes show even greater advantages over the purebreds. As shown by Antonio Bermejo Zuazúa at the Jose Antonio establishment in Valladolid, the fat tail in the first cross is negligible, the fat covering weighing on average 150 g. The F_1 Awassi × Mancha milk ewe produces a very acceptable lamb when mated to a meat sire.

The Company has imported Suffolks, Hampshires, Dorset Downs and Cadzow Prime lamb sires (an Ile-de-France, Cheviot, Border Leicester mix). Although all have given a remarkable increase in milk lamb weight and in growth rate (2 kg per week), the Suffolk and Hampshire are the most successful as all-rounders, and a further 130 rams of these breeds have been imported for the Company's own use, and for sale.

A small programme is devoted to absorbing the Awassi, and the Company now has seven-eighths bred lambs. Udders of the three-quarter bred Awassi are noticeably larger than those of the halfbreds, but it is too soon to give results for large numbers. The Mancha ewe has advantages over the Awassi such as a very short or non-existent anoestrus period, higher lambing percentages, better carcass and wool qualities, and the F_1 appears the most suitable commercial cross. However, should milk prices continue to rise, the higher-yielding but less prolific three-quarter bred Awassi may

Malpica milk sheep (Awassi × Manchega F_1)

derived by crossing Suffolk, Hampshire and Cadzow Prime lamb sires with Malpica (Awassi × Manchega) milk sheep

be acceptable. The Company has also begun selection of Manchas. Of 1 200 ewes, 300 have been identified as high yielders (130 litres), with the top 1 percent over 200 litres. These will be bred to Mancha rams from the National Flock of Valdepeñas. The Mancha has tremendous potential, but like other Spanish breeds has been sadly neglected. With quite normal treatment ewes can produce three or four lambs at a time, although infrequently, and ewes from the National Flock have given up to 491 litres of milk.

Throughout Spain, and particularly in Toledo province, a variety of Awassi crosses may now be seen. Appearance in the local Talavera stock market twice monthly has given the cross some prominence, and now the Awassi cross (or Malpica ewe) appears in the Ministry of Agriculture's price list for Spanish breeds.

Meat programme

The Cadzow Improver has been used for the last four years to produce a prolific crossbred with Mancha, Talavera and Merino ewes. However, with the passing out of business of the Glendevon Sheep Breeders station in West Lothian, which produced the Cadzow Improver, the Company may turn to the Finnish Landrace or Romanov to continue the programme. It now has 2 500 Cadzow crosses, which are kept in Cáceres province Lack of adequate water has prevented the full demonstration of the prolific ewes' capacity, but this has now been remedied with surplus water made available under the Badajoz Plan. The spring lambing of 1974 gave 195 percent lambing for the Cadzow F_1 compared with 108 percent for Merinos of a similar age and 133 percent for Cadzow cross first lambers. All figures refer to lambs born per ewe lambing. Mortality was only 6 percent.

An even more interesting development has been the general improvement in fertility of the Finn crosses over the Merinos on the same farm. Under nutritional stress the Finn cross tends to come into season and produce a lamb, whereas the Merino will either fail to mate or return to heat and remain barren.

Lambs got by meat sires could compete in carcass quality with prime lamb produced anywhere in the world. The Company has found that Suffolk and Hampshire crosses can be taken to 36 to 38 kg live weight without excess fat in the males. No ram lambs are castrated in Spain.

Now that more water is available, the main objective is to increase ewe numbers to 4 000 and lower feed costs by full feed production (apart from protein supplement) from within the farm.

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TICK-BORNE LIVESTOCK DISEASES AND THEIR VECTORS

4. Chemical control of ticks

by R.O. Drummond

The first three articles in this series on ticks and tick-borne diseases have shown that ticks are a problem because they transmit diseases, produce paralysis or toxicosis, and cause physical damage to livestock. Although only relatively few of the more than 700 species of ticks in the world are of importance to man and his domestic animals, these few species must be controlled if livestock production is to meet world needs for animal protein. Losses due to tick infestations can be considerable. For example, in Australia alone in 1974, losses due to the cattle tick (*Boophilus microplus*) were estimated to be US$ 62 million (Springell, 1974). Such losses could be cut considerably by adopting effective tick control measures. The main weapon for the control of ticks at present is the use of chemical acaricides. In this article the need for tick control is reviewed and techniques for applying acaricides to animals, classes of acaricides, strategies of tick control, and precautions when using acaricides are discussed.

Need for tick control

There are three major reasons for controlling ticks on domestic animals: disease transmission, tick paralysis or toxicosis, and tick-caused physical damage.

Disease transmission

Ticks are responsible for the transmission of a large variety of diseases that affect livestock. The major diseases include babesiosis, anaplasmosis, theileriosis, and heartwater; in addition, there are other diseases of lesser importance. The major tick-borne diseases of livestock, their symptoms, and present methods for their control were briefly reviewed by Bram (1975). Generally the ticks become infested with the causative organisms while they are feeding on infected animals. Then the organism may be transmitted from stage to stage in the tick (an example is *Theileria parva* transmitted by *Rhipicephalus appendiculatus*), or from the female tick through the egg to the larvae — an increase of several thousandfold in vector potential (an example is *Babesia equi* transmitted by *Anocentor nitens*). When the next stage or generation subsequently feeds on another animal, the organism is transmitted to that animal if it is susceptible to the disease. Therefore, the transmission of diseases by ticks can only be stopped by killing the ticks before they feed sufficiently on susceptible animals and transmit the organism. The most common method of killing ticks is by the use of chemical acaricides.

Tick paralysis or toxicosis

Several species of ticks cause paralysis or toxicosis in livestock because they inject a toxin into the animals while feeding on them. Examples are paralysis caused by the feeding of *Dermacentor andersoni*, sweating sickness caused by *Hyalom-*

Dipping cattle in dipping va

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complete coverage

ma truncatum, Australian tick paralysis caused by *Ixodea holocylus*, and tick toxicosis caused by *Rhipicephalus* species. Unless ticks are controlled, animals may exhibit severe reactions such as swelling, necrosis of skin, rise in temperature, etc. Some may die from paralysis or toxicosis.

Tick-caused physical damage

Tick infestations may cause physical damage to livestock other than disease, paralysis, or toxicosis. Included are "tick worry", the irritation, unrest, and weight loss due to massive infestation of ticks; the direct injury to hides due to tick "bites"; a loss of blood due to the feeding of ticks; the invasion of tick-infested animals by bacteria, fungi, and other pathogens; and the predisposition of tick-infested animals to infestation by other arthropods. An example of this last category is the infestation of ears of cattle in southern Texas by larvae of the screwworm fly (*Cochliomyia hominivorax*) that develop from eggs laid by female flies attracted to wounds in the ears created by infestations of the Gulf Coast tick (*Amblyomma maculatum*).

Methods of controlling ticks with chemicals

Acaricides used to control ticks on livestock or in the environment should be applied in such a manner that the ticks will be killed, the treatments will not harm livestock or applicators, the tissues of treated animals will not contain illegal residues, and the environment will not be adversely affected. Both Barnett (1961) and Shaw *et al.* (1970) have reviewed the control of ticks with acaricides.

Control off the host

Since all species of ticks spend a considerable portion of their lives off the host, these off-the-host stages of certain species can be controlled by applying acaricides to buildings, to livestock holding areas, or to the natural environment of the ticks. However, the environment must be treated with a sufficient amount of acaricide to produce maximum control. Unfortunately, many of the acaricides used for tick control are also excellent general-purpose insecticides and therefore may also be toxic to a number of the beneficial arthropods found in the same area inhabited by ticks. It is therefore important to determine that any treatments applied for the control of ticks will not harm other organisms. In addition, the effort and expense of treating large areas of land for the control of ticks plainly limit the general use of this technique. However, acaricides applied to such areas as stables, barns and small pastures can be used for the control of certain species of ticks.

Application to the host

The most popular method of controlling ticks on livestock is the application of acaricides directly to the animal host. It is important that application techniques be thorough and that the acaricides be highly effective against ticks without injuring the host.

Dipping vat

The usual way of treating large numbers of animals with acaricides is to immerse them in acaricides in dipping vats. The many different vats that have been designed all include three basic components: (1) an approach area, (2) a vat or tank in which animals are immersed, and (3) a drainage area. The approach area should be designed so as to enable the animals to enter the dip area one at a time. Often the approach area contains a footbath to remove dirt and other debris from the animals' feet before they are dipped. The vat or tank portion should be constructed of reinforced concrete or some other strong, impervious material that will not crack or leak, and should be designed to hold a sufficient volume of liquid so that the animals can be immersed completely. Such immersion is essential for adequate control of ticks. Usually the vat is long enough to

ensure that animals leaping from the entrance point cannot jump across the deepest portion of the vat, and is deep enough so that the animals will not injure themselves by hitting the bottom. The opposite end of the vat or tank consists of a series of steps to enable animals that have been immersed in vat fluids to walk steadily out of the dipping vat.

The drainage area should be so constructed that excess fluids draining from treated animals will flow back to the dipping vat proper. Sometimes these fluids are routed through a sump tank where debris, manure, and other materials are removed so that the fluid may return to the dip tank as clean as possible.

In general, dipping vats provide a highly effective method of treating animals with acaricides for tick control. However, their immobility, high initial cost of construction, and the cost of the acaricides may make vats impractical for many small ranching operations. Also, dipping vats must be managed carefully so that the dips are maintained at the proper concentration and the cattle are dipped properly.

Spray

Because of the disadvantages of the dipping vat for small operations, sprays are the most commonly used method of treating animals with acaricides for the control of ticks. Spraying equipment is highly portable, and only small amounts of acaricides need to be mixed for a single application. Spraying equipment may consist of a simple device such as the standard bucket pump; these hand-operated pumps will apply acaricides under a pressure of 27 to 45 kg. In most areas, hand-operated pumps have been replaced by motor-driven pumps capable of generating pressures as high as 90 to 136 kg. However, spraying is generally less efficient in controlling ticks than immersion in a dipping vat because of problems associated with applying the acaricide thoroughly to all parts of the animal's body. The key point with spraying equipment is that application is only as thorough as the operator. Special care is needed to treat the ears, axillae, and other relatively inaccessible areas on animals.

Spray race or spray-dip machine

The spray race and spray-dip machine are a compromise between spraying and dipping in that these devices utilize smaller amounts of acaricides than dipping vats, and the animals are treated individually by acaricides applied under pressure through a system of nozzles directed to all areas of the animal's body. A spray race is usually permanently installed and includes an entrance chute and a drain pen that collects excess fluids which are filtered and recirculated through the pump. A spray-dip machine is portable and self-contained, and is so operated that the animals remain in the machine long enough for excess fluids to drain back into the collecting tank beneath the spray chamber. However, both are mechanical devices and suffer from the ills common to all such devices. They must be constantly cared for and maintained in peak condition if they are to apply acaricides adequately and efficiently to livestock.

Hand dressing

In certain instances, as when a species of tick inhabits a limited area of an animal's body, acaricides may be applied to these areas by hand. For example, larvae and nymphs of *Otobius megnini* are found only in the ears of cattle and other animals. Also, all stages of *Anocentor nitens* are found in the ears and nasal diverticula of horses.

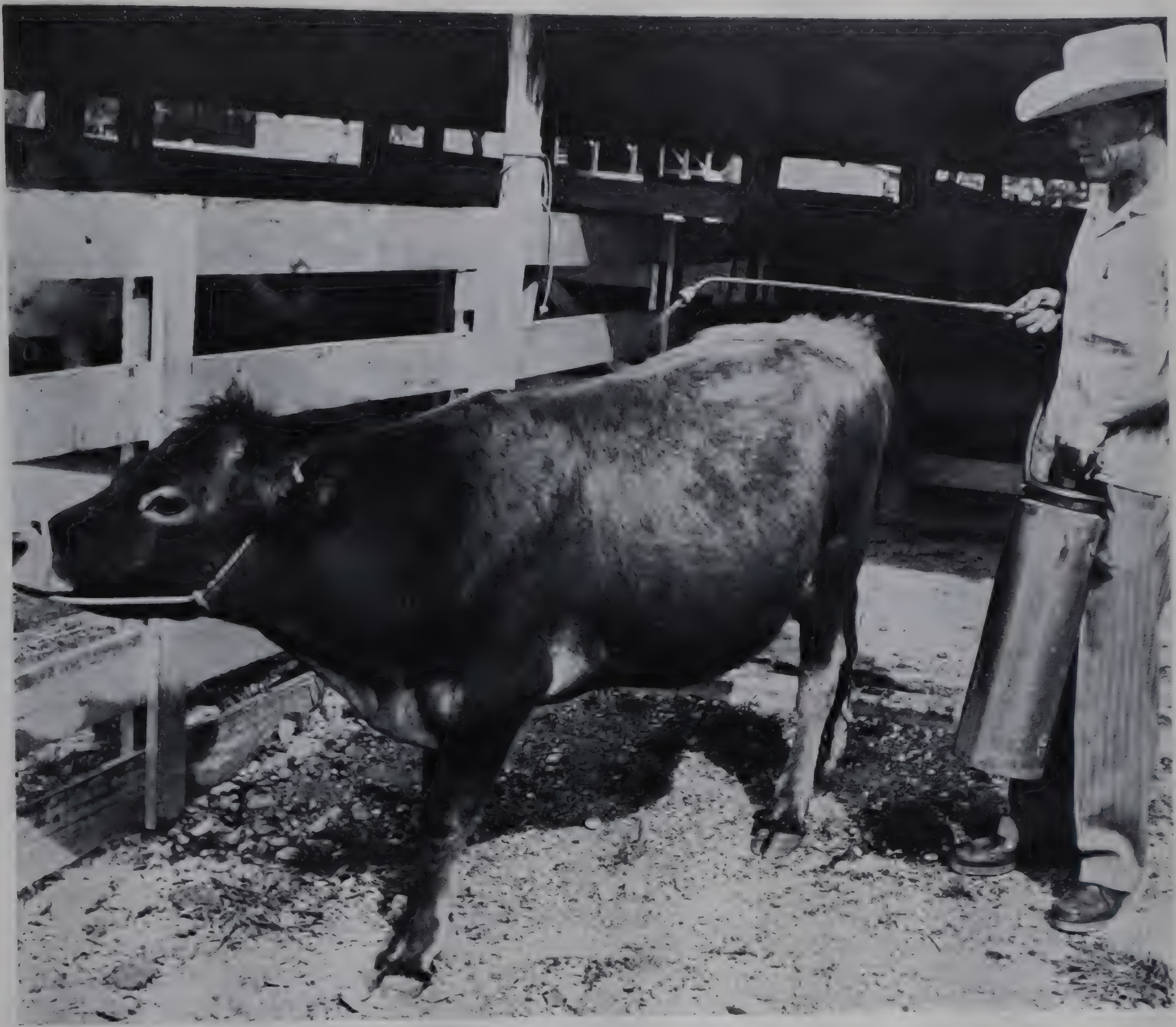
The application of insecticides with aerosols and in oils, smears, and dusts by hand to limited body areas is time-consuming and laborious, but in certain instances it may be more effective and economical (in terms of cost of acaricide) than treating the entire animal.

Other methods

Certain other methods of controlling ticks with chemical acaricides have sometimes been used. For example, oral treatments or injections of some chlorinated hydrocarbon insecticides have controlled *B. microplus* on cattle. Also, oral treatments with animal systemic insecticides have controlled several species of ticks feeding on livestock. However, allowing animals to treat themselves on a continuing basis with a systemic presents problems, and the method will probably not be practical on a large scale, though it may be useful in certain limited situations.

Another example is the tick control achieved through the use of

Infestation of Gulf Coast tick, Ablyomma maculatum, **in the ear of a cow**



Hand spraying. Application is only as thorough as the operator

insecticide-impregnated plastic ear tags or horn bands. This treatment method is similar to the "dog collar technique" used to control fleas and ticks on pets.

Acaricides

Several general groups of chemical compounds effectively kill ticks on livestock.

Arsenicals

Water-soluble forms of arsenic and arsenic-containing compounds, usually As_2O_3, have been used for many years in dipping vats to control ticks, especially ticks of the genus *Boophilus*. Arsenic is inexpensive, stable, and water-soluble, and there is an accurate vat-side test. Arsenic dips were used successfully to eradicate *Boophilus* ticks from the southern United States. Unfortunately, arsenic has a very short residual effectiveness (less than one to two days), and in most areas of the world *Boophilus* ticks have become resistant to arsenic.

Chlorinated hydrocarbons

Chlorinated hydrocarbon acaricides have been used extensively throughout the world for the control of ticks. Of particular interest are benzene hexachloride (1, 2, 3, 4, 5, 6-hexachlorocyclohexane; the gamma isomer of this compound, called lindane, possesses the greatest acaricidal activity); and toxaphene (chlorinated camphene containing 67 to 69 percent chlorine). Chlorinated hydrocarbon acaricides are generally cheap, have long residual effectiveness, and are good general-purpose insecticides for the control of a variety of livestock pests. They are also not highly toxic to livestock, though some animals have been poisoned by treatment with lindane. Unfortunately, most chlorinated hydrocarbon insecticides create residues that remain in tissues of treated livestock for fairly long pe-

Spraying of cattle with power-operated sprayer

riods. Also, a number of species of ticks have developed resistance to these acaricides. Nevertheless, both lindane and toxaphene are used in many areas of the world for the control of a variety of ticks.

Organophosphorous compounds

Because resistance to arsenicals and chlorinated hydrocarbons has developed in many species of ticks, the only available acaricides in certain areas of the world are organophosphorous compounds. Most of the large number of such acaricides available (Drummond *et al.*, 1974) are highly effective against ticks at very low concentrations. However, their residual effectiveness is usually shorter than that of chlorinated hydrocarbons, and the risk of causing acute toxicity in livestock is greater. Several tick species are now known to be resistant to organophosphorous acaricides; resistance is acutely present in *B. microplus* in Australia and several other countries (Wharton, 1974).

Other compounds

Carbamate acaricides are used in special situations when ticks have become resistant to most organophosphate and chlorinated hydrocarbon acaricides. In addition, several other new acaricides have appeared on the market to be used for the control of resistant ticks. Especially promising are the formamidines that have demonstrated outstanding acaricidal activity (Roulston, 1973). The use of chemical acaricides continues to produce resistance in ticks. It is obvious that ticks, especially *B. microplus*, are highly adaptable insects and will probably respond to any challenge posed by a new acaricide. It is therefore imperative that the effective acaricides presently used be applied correctly and efficiently so as to prolong their usefulness as tick control agents.

Control strategy

In any situation the strategic (or most effective) use of acaricides for the control of ticks will depend upon a number of factors including the life cycle of the species of tick to be controlled, the urgency of the need in terms of disease transmission, the seasonal activity of the tick, and government regulations.

Certainly an acaricide must be directed against the susceptible stage of the tick. The strategy in controlling a one-host species such as *B. microplus*, which attaches to animals as larvae and moults on the host, consists of treating animals at 14- to 21-day intervals so the females are killed before they can finish engorgement. The strategy in controlling a three-host species such as *Amblyomma americanum* consists of treating animals at 7- to 10-day intervals so as to kill adults moving from the environment to attach on

the animals. The strategy in controlling *Otobius magnini*, another one-host species that slowly engorges in the ears of livestock, may consist of a monthly or bimonthly treatment because of the low reinfestation pressure and low biotic potential of this species. Since the strategy of tick control depends so heavily on the biology of the species to be controlled, the need for correct identification of ticks and current information on their biology cannot be overemphasized.

Urgency of need in terms of disease transmission can be illustrated by the need for control of *Rhipicephalus appendiculatus*, which transmits East Coast fever to cattle. Since the disease is transmitted from stage to stage in the life of the tick, an infective adult can infect a susceptible animal within two or three days after it attaches. Therefore, with an acaricide that has a short residual activity, cattle must be treated every three to five days to prevent transmission of the disease.

The seasonal activity of the tick should logically determine the time of application of acaricides to livestock or to the environment. Treatments should be applied when they will provide the maximum benefit in terms of reduction of tick populations. A "strategic" scheme for treatment does not necessarily mean treating animals at the time tick populations are at their peak. It could well mean treating when animals are only lightly infested so as to reduce the populations that survive through stress periods such as dry seasons, low temperatures, etc. Again, considerable information concerning the life history, seasonal appearance and biology of ticks must become available before such "strategic" treatment can be effectively utilized.

The use of tick control measures in government-sponsored or regulated eradication campaigns is usually dictated by the need for complete, thorough and frequent treatment of livestock on a compulsory schedule. In the southern United States a compulsory scheme that included the dipping of cattle every two weeks in 0.18 to 0.22 percent arsenic was successful in eradicating *B. annulatus*. Additional factors were pasture rotations and quarantines to prevent movement of livestock.

Precautions

Acaricides must be used to control the many species of ticks that affect livestock, but these acaricides can be toxic to livestock and humans, can create illegal residues in tissues of animals, and can be destructive to the environment if they are not used and handled in a safe and correct manner. The following are some precautions to follow when using acaricides for the control of ticks (modified from U.S. Department of Agriculture, 1967).

1. Use only those acaricides recommended and approved for use on livestock by a competent authority, usually a government official, recognized agricultural agent or adviser, livestock production specialist, veterinarian, or other person with specialized training. Often lists of recommended acaricides are published by responsible government agencies.
2. Use a formulation of the acaricide that is approved and especially designed for use on livestock. There are too many examples of poisoning and death of livestock due to treatment with a recommended acaricide in a formulation designed for use on plants. Especially, only those formulations designed specifically for dipping vats should be used in dipping vats.
3. Follow the label directions exactly. The label contains all the information on dilution, time of retreatment of animals, antidotes for poisoning, methods of disposing of unused insecticide, and other important facts.
4. Be sure that spraying equipment is clean and working properly, and especially that it provides sufficient agitation to allow for thorough mixing of acaricides.
5. Be aware of safe practices when mixing or applying acaricides. Do not eat, drink or smoke during application; wear special clothing that can be changed after the day's application is finished; use simple precautions when mixing and preparing acaricides; if accidentally exposed to an acaricide, wash it off thoroughly and change clothes immediately; do not store acaricides near food or in other than original containers.
6. Learn to recognize signs of acaricide poisoning in livestock and humans to avoid delay in applying antidotal measures.
7. Dispose correctly of all containers, unused concentrate, and used diluted acaricide to avoid contamination of the environment.

The safe use of acaricides is essential to an efficient, well-run programme for the control of ticks. Although millions of animals are treated and millions of kilograms of insecticides are used yearly, this safe use should not be taken for granted. To avoid accidents and misuse, it is necessary to continually review and employ safe use precautions and procedures.

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Milk recording in developing countries

Sound dairy management involves keeping good records. Once a government realizes that milk recording should complement breeding programmes, farmers must still be convinced that they have something to gain from keeping records. Here are ways in which milk recording systems in developing countries can be adapted to the needs of farmers and governments.

by U.B. Lindström

The first milk recording organizations were formed in Denmark in 1895 (Johansson, 1961). The recording movement spread rapidly and now plays an important role in all countries with an advanced dairy industry. In some countries (e.g. Denmark, Israel, the Netherlands, Norway and Sweden) more than 50 percent of dairy cows are recorded. On the other hand, in most developing countries production figures on individual animals are usually available for only a tiny proportion of the total cow population (McDowell, 1972). For example, in Kenya the number of officially milk recorded cows is about 10 000 out of a total cow population of some 3 million, of which over 800 000 are high-grade European animals (Livestock Recording Centre, 1974). In many developing countries there is no systematic recording at all. What has brought about this situation? Is it possible to develop simple milk recording systems adapted to the needs of the developing nations? This article discusses these questions and pays special attention to aspects of recording related to the selection of animals.

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Objectives

Milk recording has two main objectives:

1. To help the individual farmer to produce milk more efficiently, i.e. more economically.
2. To provide data for government administrative, research, breeding and extension purposes.

Both objectives are of course equally important, but it should be recognized that if the individual farmer cannot be convinced that he/she has something to gain from the practice, it is very difficult to develop extensive recording systems. One should therefore avoid emphasizing the over-all national benefits too much, because otherwise many farmers will believe that milk recording serves only the interests of various official bodies.

The starting point in all recording schemes should be the farmer, how to get him/her to see that it really pays to keep some simple records. If one succeeds in this, the collection of data, and cooperation in other matters, will be much easier.

Integration with other services

One of the weakest points of many schemes is that milk recording is carried out more or less divorced from other related activities. Fig-

In most developing countries milk recording is either non-existent or very rare. Subsidies and economic incentives are needed to promote record keeping

ure 1 shows an example of desirable integration of data collection and dissemination of results in the field of milk production. The activities of the central dairy board or a comparable body supervising the dairy industry should be closely coordinated with those of the AI organization, the extension services, the milk recording organization and the research institutions. Only too often the channels of communication between these organizations are practically non-existent. In Figure 1 information flows in two main channels: "down" from the various governmental and other bodies, and "up" from the farmers and advisers working in the field.

If only the first channel is used (as is often the case), the scheme cannot be fully effective. A system with built-in feedback which gives both small and large farmers and extension workers adequate opportunities to make suggestions has better chances of developing along the right lines. Stigler (1961) says: "One should hardly have to tell academicians that information is a valuable resource: knowledge is power. And yet it occupies a slum dwelling in the town of economics."

Applied to the field of milk recording we could say: Listen to the man/woman in the field, and let us make the best use possible of the information he/she can provide us.

Problems and needs

Apart from the general lack of funds, the main problems in setting up and running milk recording schemes in developing countries are:

1. Low educational level of farmers.
2. Lack of qualified extension workers and recorders.
3. Few incentives for farmers to record their cows.
4. Small average herd size.
5. Poor communications.
6. Unrecognized need for progeny testing and other breeding programmes.
7. Poor data collection and processing facilities.

Although the problems are serious, they are not impossible to cope with. For example, a small average herd size and difficult communications have not prevented the expansion of milk recording in Norway and Finland.

It is difficult to develop extensive milk recording services in a country if the government does not actively

promote them. One of the many ways in which the authorities can promote milk recording is through the price paid to the producer.

A fair (high) price automatically increases interest in producing more milk, i.e. in feeding and managing the animals better and in getting cows of higher genetic quality, and this usually also generates more interest in records.

Another general incentive for creating more interest in records is to pay the farmer not only according to the quantity of milk, but also on the basis of the content of fat and/or protein. In most developing countries the farmers are paid only on the basis of quantity, perhaps with a low minimum requirement on the fat percentage (McDowell, 1972). This does not encourage detailed record keeping and discriminates against breeds with a high solids content in the milk, and thus usually against the indigenous breeds. In addition, there is little justification for producing low-protein milk by favouring quantity at the expense of quality. Payment should be for both quantity and quality, the latter preferably determined by the protein percentage.

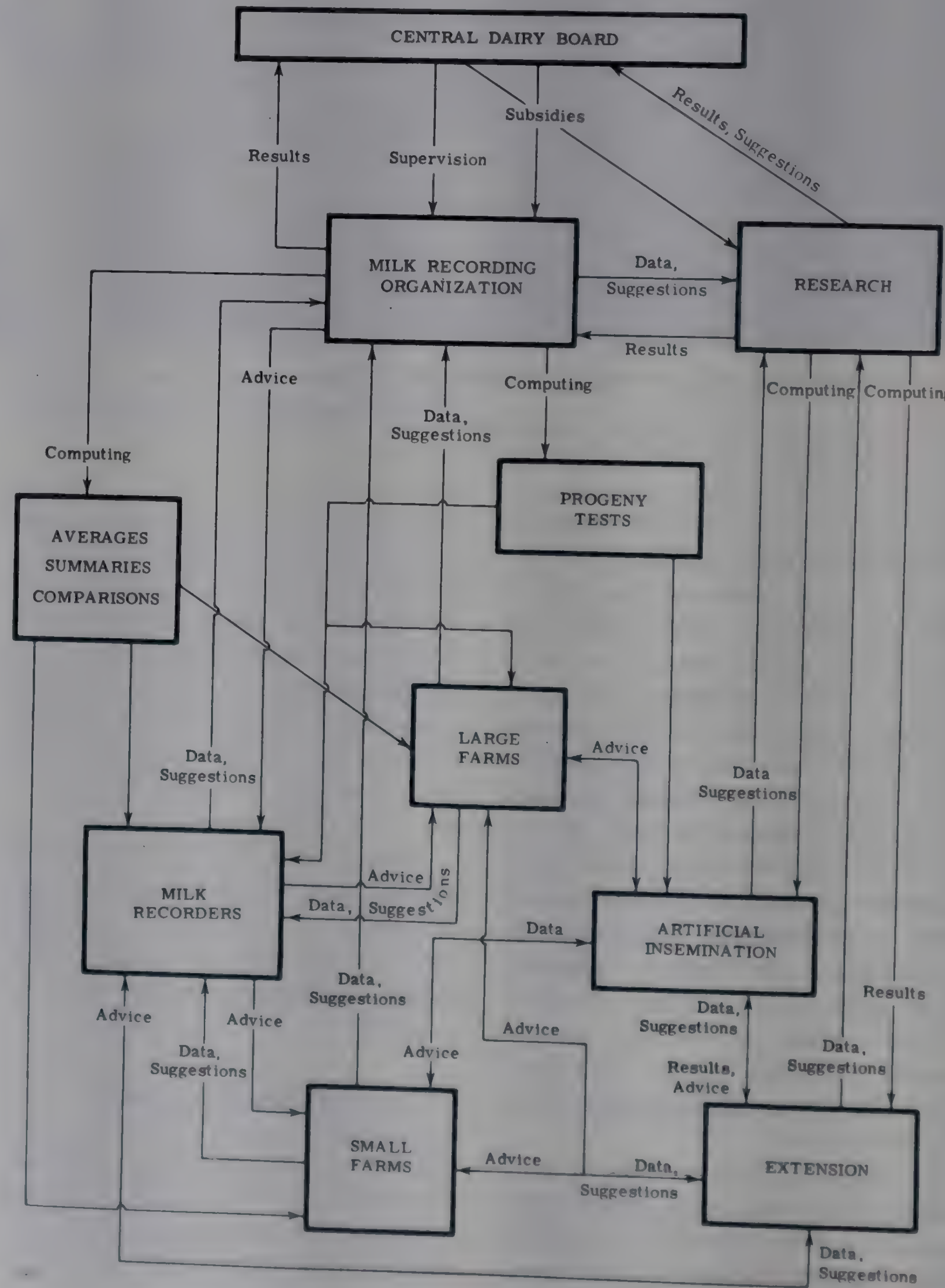
Incentives. General incentives are helpful but are usually not sufficient to get large numbers of farmers to join a milk recording scheme. Therefore, one should seriously consider other ways of encouraging milk producers to keep records. In Finland a popular saying has it that "Money is the best extension worker". If farmers could actually be paid for keeping records and sending them to the authorities, this would obviously be the most efficient incentive. Even if this system cannot be used generally, it could be tried when starting and building up a scheme in a developing country. And farmers willing to cooperate in a progeny testing programme should certainly be paid a fee for each daughter record.

Other possible incentives are:

- Farmers belonging to a milk recording scheme would get free of charge sound advice on how to manage, feed and breed their animals at regular intervals.
- Farmers belonging to such a scheme would get all inseminations without cost, or very cheaply. This would simultaneously promote both recording and AI. If AI is not available, good bulls could be put at the disposal of record-keeping farmers without extra cost.

Subsidies. Apart from incentives, recording and associated extension activities should be subsidized directly or indirectly by the dairy industry or by the government. In developed countries funds are often accumulated by issuing a small levy (e.g. US$ 0.05 per kg) on all milk delivered to the dairies; milk recording is financed or subsidized with these funds. For example, in Norway the farmer pays about 15 percent of the costs of milk recording, and the rest is financed by the dairy industry or other authorities. In developing countries, subsidies should play an even more important role. At the start of a milk recording scheme, when the number of participating herds is small, farmers should probably not be levied any charge. Even a very

Figure 1. **Schematic outline of desired flow of information in milk recording and associated activities**



Recording milk yields of Sahiwal cattle in Kenya under field conditions

low fee per cow seems to put small farmers off joining the recording service. In the beginning it is more important to interest the farmers in recording than to make the scheme self-supporting. Gradually, as the scheme is built up, the services offered are improved and the farmers begin to see the benefits, a small fee can be charged. It should be stressed that cooperation between the milk recording sector on the one hand and AI, extension and research on the other, should be as close as possible. The various subsidies, incentives and services offered should be well coordinated so that they are not in conflict with each other. All field workers should get an all-round training. AI technicians should, for example, be well acquainted with the milk recording scheme, and similarly the recorders should be familiar with AI operations.

What does the farmer want?

As pointed out earlier, the low educational level of farmers is one obstacle in all improvement programmes in developing countries. How serious is this problem? Are farmers willing to cooperate? Table 1 gives some results of a survey carried out in Kenya at the end of 1972 among small dairy farmers (Lindström and Lindström, 1974). Most of the farmers were already giving extra feed to their cows (about half of the herds were in the high-potential areas of Kenya). Nevertheless, 80 percent of the farmers felt that they needed more advice on keeping dairy cattle. There was no specific need that stood out; most farmers wanted advice on dairy cattle management in general. Only one quarter of the farmers mentioned agricultural and extension officers as sources of information on how to manage their cows. The most common complaint was that the extension officers never or too seldom contacted the farmers. "They are only in towns," "Never seen them in these parts," "Officers are only seen in public meetings" were common remarks throughout.

These findings indicate that farmers would be willing — and in fact would be quite happy — to cooperate with extension personnel. The problem is not only to get enough extension field workers, but also to utilize them effectively. With better planning and organization of the field work, more farmers could be reached and persuaded to participate in milk recording schemes in most developing countries. For example, when Kenya Milk Records employed an extension officer travelling round to farms, there was a substantial increase in

the number of participating herds (Livestock Recording Centre, 1974).

Collecting information from farmers

But are small farmers really able to collect useful information? Table 2 shows some of the information obtained from the above survey. The most encouraging result was that most of the farmers surveyed seemed to be quite well aware of how much their cows produce. Of course, the production figures given were not exact, but the farmer was generally able to place his cows in order of merit. From the point of view of enrolling more herds in a milk recording scheme, this is promising. Thus it should be possible to interest farmers in recording the yields in a more systematic and detailed manner once they have started observing their animals. On the other hand, the survey showed clearly that the identity of the sire of the cow in question was hardly ever known, even when the owner reported it to be an AI sire. This was so despite the fact that some of the farmers using AI had been provided with a card and file for keeping track of the matings and calvings of their cows. Apparently the farmers did not realize why this should be done and what use there was in knowing the identity of the sire. One can hardly blame them for this, and one should certainly not interpret the result as meaning that it is impossible to get the sires recorded. However, at the beginning it would be desirable to make this task the responsibility of AI technicians, milk recorders and extension officers.

What should be required of a milk recording system in a developing country? The following is by no means a complete list, but the requirements given are probably the major ones:

- The scheme must be simple, i.e. involve little "paper work" for the farmer.

- The scheme must appeal to the average farmer; he/she must feel that it benefits the management of the herd.

- The direct costs to the farmer should be small.

- The records kept should enable the farmer to identify his best and poorest producers, and should make it possible to progeny test bulls.

- The information from the records should be made available to the farmer quickly and in simple form, and should be utilized for extension and research purposes.

- The milk recorders should visit each farmer at least once a month to maintain contact and give advice.

The routine weighing of the milk from each cow at regular intervals is not in itself the most important aspect of recording. The most important thing is the utilization of the records obtained. Unfortunately, many schemes have given priority to the routine collection and tabulation of figures, and to a large extent have neglected the main task of milk recording. There is little justification for continuously collecting detailed records if they are not properly utilized.

Table 1. **General information provided by 146 small dairy farmers in Kenya**

Item	Percentage of all farmers interviewed
Extra feeding practised	82
Need for more advice	80
Complaints on extension	51
Complaints on AI	39
Information on management of cows obtained from:	
Farmers' training college	43
Agricultural and extension officers	25

Table 2. **Information on dairy cattle production provided by 146 small dairy farmers in Kenya**[1]

Proportion of cows with known milk yield	%	87
Reported average milk yield per cow per day		
After calving	*kg*	9.7
Usually	*kg*	6.6
Average monthly income per cow	*K.Sh*	49
Proportion of cows with AI sire	%	57
Sire of cow known	%	< 1

[1] Data are for 418 cows, of which about three quarters were European purebreds or crossbreds.

Collecting and processing data

The fewer figures that are collected and the simpler the recording sheet is, the better are the chances of making the scheme work. Table 3 gives examples of recording sheets that would be completely adequate for both the farmer and the official sector (Mahadevan, 1966). When the recording sheet is introduced, two things should be stressed:

Table 3. **Simple recording sheets**

A. — Permanent information (one sheet per cow)

Cow's ear (tattoo) No. .... Cow's breed ....

Cow's birth date .... Sire of cow ....

Dam of cow ....

Lact. No.	Service dates	Bulls used	Calving date			Calf		Lactation length (days)	305-day production (kg)	Total production (kg)	% fat or protein	Days dry
			Day	Month	Year	Sex	Ear No.					
1												
2												
3												

B. — Test day production

Test day	Cow No.	Milk yield kg (AM or PM)	% protein (% fat)	Remarks on calving, services, drying off, illnesses

- Proper identication of the animal is a must. Preferably all calves should be ear-notched or tattooed as early as possible.

- The records must be used continuously for feeding and management purposes; otherwise, there is little point in putting down the figures.

In the beginning farmers should get detailed advice from an experienced extension worker on how to keep and use the records. If possible, the farmers should be visited at intervals of two to three weeks, and at least three times in the first two months. After that, regular monthly or bimonthly visits are required to maintain contact and ensure good follow-up.

How the farmer's records should be collected and processed depends on prevailing conditions. As long as the number of participating herds is small, the necessary calculations can easily be made on simple desk calculators. As more herds and cows are enrolled, the use of a minicomputer, or even a computer, may become justified. This would ensure fewer errors and rapid processing at a reasonable cost with the modern equipment now available. At present, in many developing countries the same figures are transferred

several times before final processing, resulting in many errors. It is important that the farmers get the results as soon as possible. These should relate to current and total production for each cow and herd, fat or protein percentage, service and calving dates, etc. Summaries and recommendations should be sent to the farmers at regular intervals, not just once a year. Especially at the beginning, figures on age at first calving, dry periods, calving intervals, and lactation lengths should be carefully explained and attention drawn to any irregularities.

For comparison, each farmer should also receive averages for other herds in the same area and elsewhere in the country.

Table 4. **Accuracy of estimated lactation yields of 1 097 cows of four European breeds and the Sahiwal breed on 10 farms in Kenya, 1969-72** [1]

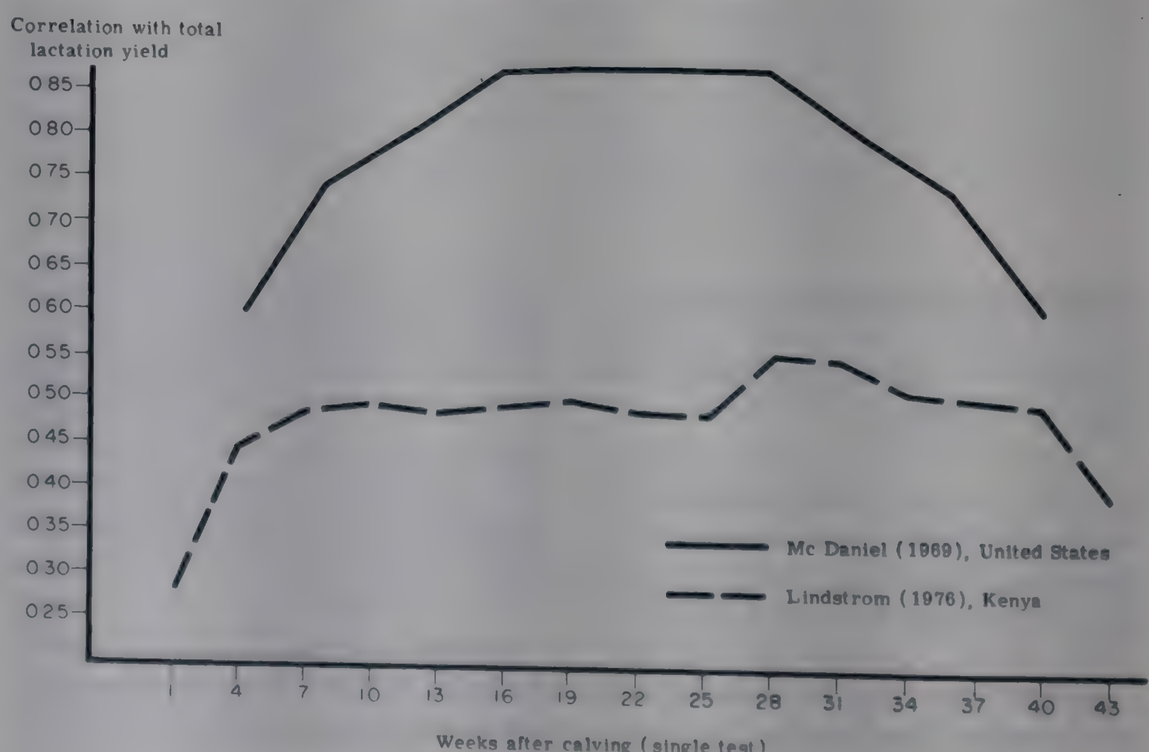
Recording	Correlation with actual yield (within farm and calving season)	Average difference: estimated minus actual yield = d		95% confidence interval for estimated individual yields − d ± 1.96 × standard deviation	
		kg	% [2]	*kg*	% [2]
Weekly	0.994	39	1.41	−201 to +279	− 7.3 to +10.1
Biweekly	0.991	43	1.55	−251 to +337	− 9.1 to +12.2
Monthly	0.978	37	1.34	−422 to +496	−15.2 to +17.9
Bimonthly	0.943	42	1.52	−689 to +773	−24.9 to +27.9

[1] Actual yields were based on daily weighings of milk. — [2] Percent of actual average yield (2 767 kg).

Accuracy of individual yields. How simple can a scheme be and still give sufficiently reliable results? The first question in this connexion concerns the interval between weighings and how often samples for fat and protein determinations should be taken. A number of studies, made mainly in Europe and North America, have shown that recording milk once a month is accurate enough for individual selection and once every two months for progeny testing (see literature review by McDaniel, 1969). Table 4 gives some results from a study of 10 herds in Kenya (Lindström, 1976). The average error is small: even for bimonthly testing it is only about 1.5 percent of the actual mean. However, due to the large standard deviations, the individual errors for biweekly testing are of the order of −9 to +12 percent of the actual yield, i.e. −251 to +337 kg. Prolonging the recording interval to one month increases the error to ±400 to ±500 kg. Thus it would seem that in Kenya one should preferably not go beyond a 14-day interval for recording if a relatively high accuracy in selecting individual cows is to be maintained. Moreover, for managerial and educational purposes biweekly testing seems desirable, at least at the start of the scheme. These conclusions may be valid in many other countries with similar conditions. On the other land, as far as selection accuracy is concerned, there is no reason to continue with the present Kenyan system of weighing the milk every day. If large farmers wish to keep daily records in order to check if milk is stolen, it is up to them to do so, but one should not make the majority (i.e. the small farmers) follow the same system.

As regards the collection of samples for fat and protein determinations, several studies (McDaniel, 1969) have shown that monthly recordings generally (at least for fat percentage) give a somewhat lower accuracy than monthly recording of milk yields. For selection purposes they are, however, sufficiently reliable, although more frequent testing would be desirable from a managerial point of view. However, the difficulties in collecting and distribut-

Figure 2. **Correlations between single-test day production and total lactation yields**

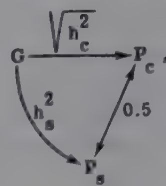


ing milk samples in developing countries make this unrealistic in most cases.

Accuracy of progeny testing. For progeny testing purposes, relatively few observations per individual cow should still give a satisfactory accuracy if enough daughters are sampled. Figure 2 shows average correlations between single-day test production and total lactation yield as calculated by McDaniel (1969) for several studies in the United States, and corresponding results from Kenya (Lindström, 1976). In the latter study the maximum correlation of about 0.5 during the first six months is reached some 10 to 12 weeks after calving. In the former, the highest correlation of 0.87 is reached some 16 to 20 weeks after calving. In Kenya it appears that the wide fluctuations caused by climate and management, in combination with the relatively low absolute level of milk production, result in a lower accuracy of single observations. This may also be true in other developing countries, and it should be taken into account if progeny tests are to be based on single-test day production.

However, even a correlation of only 0.5 is no hindrance for progeny testing bulls. Assuming the heritability of a complete lactation yield, h_c^2, to be 0.3 (Meyn and Münsterer, 1968), the heritability of a single test day, h_s^2, can be calculated from:

$r^2_{GP_s}$ =



, where G = genotype
P = phenotype

$$h_s^2 = r^2_{GP_s} = (\sqrt{h_c^2} \times 0.5)^2 = (0.55 \times 0.5)^2 = 0.0756$$

Thus a progeny test based on 100 to 150 daughters, for example, would still give an accuracy of 0.66-0.74, i.e. sufficient for picking the best bulls.

Getting 100 to 150 daughter records per bull may seem difficult or impossible in a developing country. It obviously depends much on how the recording of yields and the sampling of bulls are organized. By carefully distributing semen from the bulls to a number of selected herds, and preferably by paying the owners for each daughter record, enough bulls can be tested. The testing can be carried out either separately or as part of the ordinary milk recording system. In the former case, the yield of daughters of selected young bulls would be recorded, either by special recorders or by the farmers themselves, for about two to three months at two-week intervals, starting some 10 to 12 weeks after calving. This system would make it possible to test enough bulls per year at a fairly low cost. Generally, it would of course be better if the progeny tests could be calculated as a by-product of ordinary milk recording. But this is often not possible, and one should then not hesitate to set up a separate progeny testing scheme; later on it can easily be incorporated into the routine milk recording system. In Kenya the experiences of concentrating the testing of batches of young bulls in large governmental and private herds have been good (Livestock Recording Centre, 1974).

How to test

In order to extend recording to as many herds as possible, to keep costs down, and to employ recorders gainfully (i.e. in actual extension work), the routine weighing of the milk should be left to the farmer. The recorders should, of course, supervise the weighings periodically, but this is not their main job. Moreover, there is no need to weigh the milk in both the morning and the evening. Many studies (McDaniel, 1969) have shown that alternate morning-afternoon recordings are almost as accurate as morning and afternoon recordings. Also in Kenya, one weighing a day gave only slightly lower correlations with actual yields than two weighings a day (Lindström, 1976). How then should the weighings be done? If the farmers can be provided with scales or measuring cylinders free of charge, the yields can be estimated fairly accurately. The equipment now available is so simple that any farmer can easily learn to master the technique. But if exact measuring equipment cannot be provided, the yields can still be estimated with satisfactory accuracy for most purposes. For example, the buckets, pails, gourds, bottles, etc. ordinarily used by farmers when milking could be marked into 1- to 2-kg sections by use of exact measuring equipment. Even illiterate farmers will then be able to set down the necessary figures satisfactorily. In the survey mentioned earlier, small farmers in Kenya were generally able to state fairly accurately the number of bottles or gourds of milk of a certain volume each cow produced. It would, of course, be preferable if all farmers could be provided with a simple bucket or bottle premarked into easily readable sections. The dairy industry would certainly benefit from the widespread use of some kind of recording instrument, even if these have to be supplied free.

Protein percentage

In the developing countries, many of which suffer from an acute shortage of animal protein, it is often suggested that protein determinations of the milk should be included in the recording scheme. The cheapest equipment (half automatic) for measuring protein content now costs around US$ 2 200 to 2 500. Fully automatic machines with a capacity of 150 to 180 samples per hour (also determining the fat and lactose content) are available for US$ 65 000 to 70 000. With a very limited number of such machines, protein determinations could be made centrally for a whole country. The milk samples can be sent for determinations either by the recorders or by the farmers themselves, or they can be collected in connexion with milk deliveries to the dairies. For example, in Finland, after collection and addition of preservative (potassium

bichromate), 50-ml test bottles are sent to a central laboratory by mail. The results are returned by mail to the farmer either directly or via the recorder. There is no reason to assume that similar systems would not work in developing countries. In the beginning, farmers must naturally get detailed instructions and see demonstrations on how to collect the samples. The recorder should supervise the sampling the first two or three times; after that the farmers should be able to do it themselves.

When introducing new practices, it is important to remember the woman in the house. Usually it is the men who are approached, talked to and sent to attend courses, whereas in practice it is the women who often do the actual job, and are therefore the ones more in need of advice. In fact, in the developing countries women would probably be as good or even better extension workers/milk recorders than men.

The importance of breeding programmes

Had the need for sound progeny testing and other breeding programmes been generally recognized in developing countries, milk recording would certainly have got more support. The argument against investing in breeding programmes is often: "The genetic capacity of the animals is not the limiting factor; we must first improve the veterinary, feeding and management practices, and then we can set up breeding schemes." Such statements completely ignore the fact that good records are the very basis for sound management of animals. Moreover, who can really say when the genetic capacity is the limiting factor and when it is not? Perhaps it seldom is in the high-potential areas of the developing countries where foreign (European) stock can be used, although one can not be too sure about that either. But in medium- and low-potential areas the genetic capacity certainly is a limiting factor, and it is difficult to see how that can be improved without good breeding programmes based on adequate recording systems. Furthermore, if a strain much better suited to a poor environment than existing ones can be developed by breeding, it becomes easier to spread its genes — much easier in fact than it is to tell farmers and nomads how to improve the environment of their animals.

Summary

The starting point in all recording schemes should be the farmer. The recording scheme should be intimately integrated with the activities of the extension service, the AI organization, the research institutes and other bodies working in the same field. Farmers, recorders and extension workers should be given ample opportunities to make suggestions about the scheme.

The authorities should actively promote milk recording through subsidies and incentives. Possible incentives are:

- Paying for the fat and protein contents of the milk.

- Giving free advice on feeding and management to farmers supplying records.

- Providing farmers participating in recording with AI or good bulls free of charge or at low cost.

- Paying for daughter records of selected young bulls.

In Kenya a survey showed that most small farmers, many of whom kept no records, knew the approximate production of their cows. When taking into account the fact that the farmers were also very eager to get more advice on dairy cattle management, it should be possible to set up simple recording schemes based on farmers' weighings.

The recording must be followed up by regular extension visits. Advice should be given not only to men, but also to women, as the latter often carry out most of the practical work. In order to encourage production of animal protein, it would be advantageous to include determinations of the protein percentage of the milk in the recording scheme.

Under Kenyan conditions, biweekly testing for milk yield gave errors of −9 to +12 percent of the actual yield, whereas monthly testing increased the error to −15 to +18 percent. For managerial and educational purposes, biweekly testing seems advisable. The testing could well be done on an alternate morning-afternoon basis. For progeny testing purposes, 100 to 150 daughters per bull, recorded for two to three months at biweekly intervals starting 10 to 12 weeks after calving, would give an accuracy of 60 to 70 percent.

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Reproductive performance of high-producing pigs under tropical conditions

by Jörg Steinbach

About one third of the world's pig population is found in the tropical regions, mostly in Latin America and Asia, and there are good prospects for expansion in many African countries. Although the pig is potentially a very fertile and fast-growing species, in many parts of the tropics it has a poor reproductive performance and a slow growth rate. This low productivity, which is reflected in Maner's (1974) estimate of extraction rates of 20 percent of what is achieved in the industrialized temperate countries, is caused by the poor genetic endowment of indigenous pigs and by inadequate management under the extensive conditions of subsistence farming. This article attempts to explore the fertility potential of genetically high-yielding strains of pigs under conditions of good management in a typical tropical climate in southern Nigeria (Steinbach, 1975).

The ultimate result of reproduction in a pig herd, i.e. the number and weight of piglets produced per sow, depends upon a complex interplay of environmental factors and internal processes. The more important actions and interactions that affect pig production are outlined in Figure 1.

Among the environmental factors, climate is of great importance in tropical areas where pigs are constantly exposed to temperatures above their thermal comfort zone. Climatic stress is aggravated by high endogenous heat production, particularly during pregnancy and lactation. The combination of high ambient temperature and a high rate of metabolic heat production can easily offset the thermal balance of productive pigs and affect the neuro-endocrine control system, the functioning of the reproductive tract and the sexual behaviour patterns of both male and female pigs. There is no doubt that high environmental temperatures adversely affect directly or indirectly (by way of reduced feed intake) the production of hormones and gametes, and thus reproductive efficiency. The quantitative relationship between heat stress and many of the individual reproductive processes referred to in Figure 1 remains to be evaluated. Nevertheless, the following discussion of some of the effects of a tropical climate on the fertility traits of the boar and the sow may be of value to those engaged in the development of methods to increase pig productivity in tropical countries.

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Fertility of the boar

The reproductive performance of the boar is determined by the rate of sexual development, by mating behaviour, and by the quantitative and qualitative aspects of semen production.

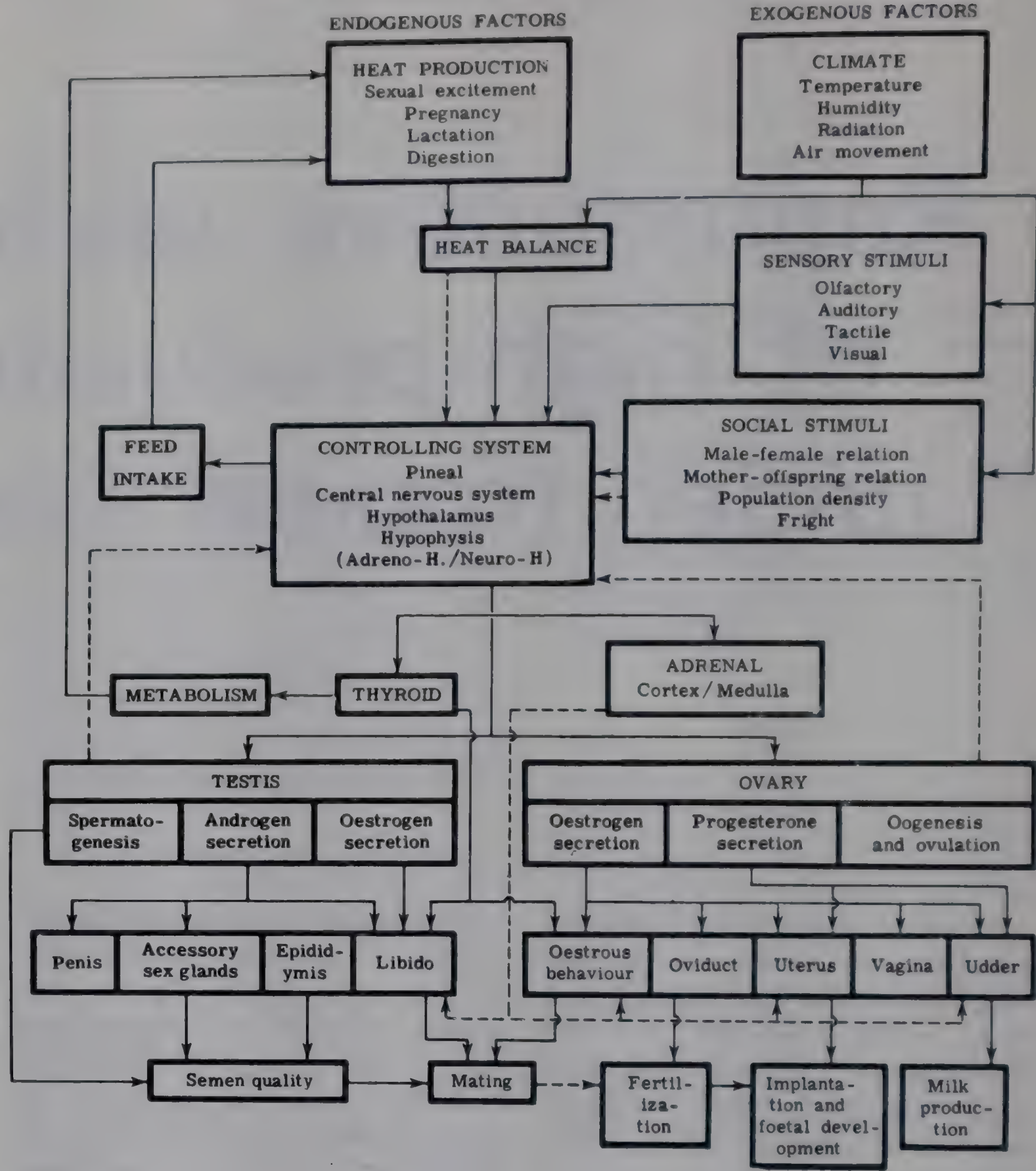
Puberty. In the tropics, the genital tract of a well-fed boar develops fast between 5 and 8 months of age, and puberty is attained at about 7 months, when the testes (indicators of spermatogenic potential) and the vesicular glands (indicators of male sex hormone secretion) attain their maximum relative size. The onset of sexual proficiency is thus delayed by about one month compared to experience in temperate countries. The later age at puberty is undoubtedly the result of retarded body growth which is caused by the heat-stressed boar's lowered feed intake.

Mating behaviour. The sexual behaviour of boars can be studied by using the technique of semen collection. Normally, boars can be easily trained to accept the dummy sow, although there are considerable variations in libido among individuals and breeds. For instance, Large White are sexually more aggressive than Landrace boars. In our semen collection studies we were able to detect seasonal (and apparently temperature-dependent) changes in sexual behaviour. The lack of libido, as measured by the reaction time and/or by the boar's refusal to mount the dummy, followed the seasonal trends in temperature (Figure 2).

The relationship between ambient temperature and the boar's insufficient sexual interest in mounting and completing ejaculation was significant ($r = 0.59$), as was the association between temperature and reaction time ($r = 0.65$). The lack of sexual interest during the hotter season of the year may be related to reduced testosterone levels in the plasma of the heat-stressed boar. In addition, the boar's sexual interest may have been adversely affected by the influence of the thyroid, which is largely inactivated during heat stress.

Semen quality. Our studies on the quantitative and qualitative aspects of the ejaculate indicate that the sperm production rates of boars in a tropical environment are comparable with those obtained under temperate climatic conditions. Yet there are seasonal differences in the concentration of spermatozoa in the semen, and thus in the total number of sperm cells harvested during semen collection. We obtained ejaculates averaging more than 60 000 million spermatozoa in October, compared with less than 30 000 million in April, i.e. two months after the coolest and the hottest months of the year respectively. These results suggest that a rise of 1°C in the mean monthly temperature will lead to a reduction of 4 000 million sperm cells in each ejaculate about two months later — which is the period taken for the spermatozoa to develop and mature in the testis. The reduced

Figure 1. **Effect of environment on pig fertility**



Semen is collected from a Swedish Landrace boar by using a simple dummy and an artificial vagina

Figure 2. **Effect of ambient temperature on sexual behaviour of boars**

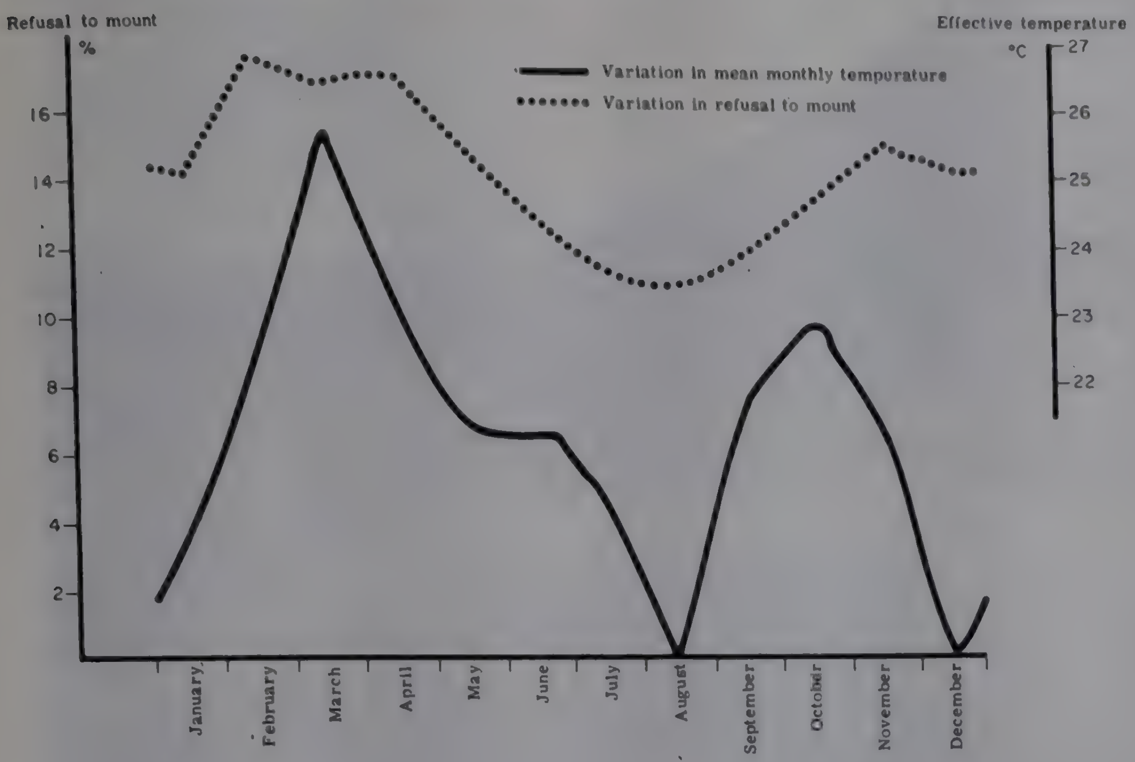
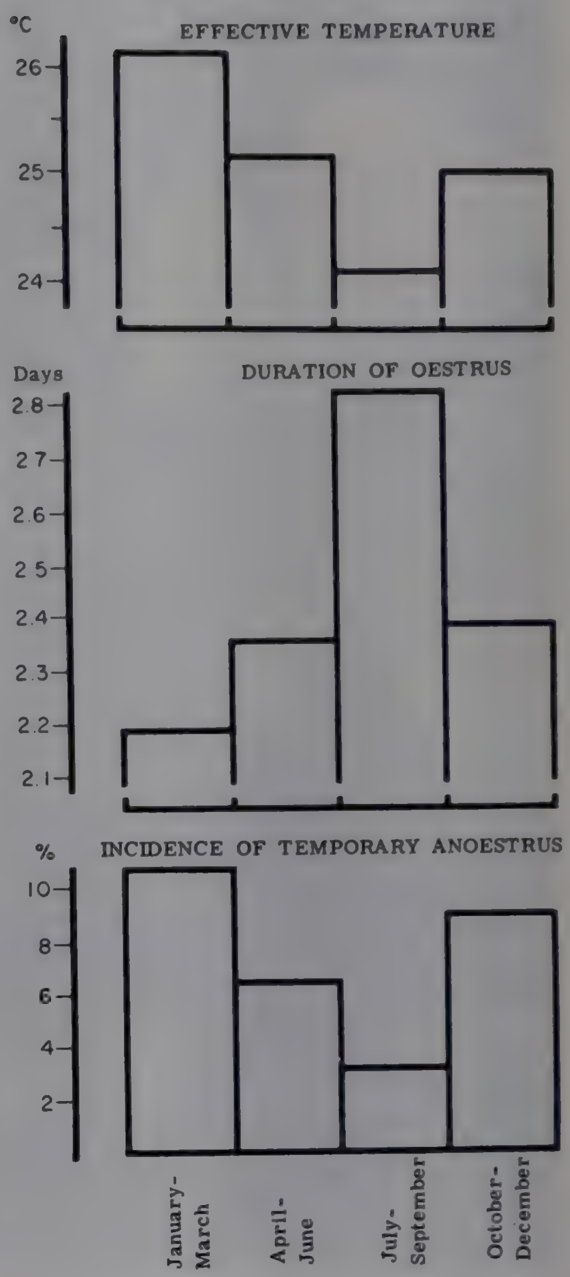


Figure 3. **Effect of ambient temperature on oestrous behaviour of sows**



production of testosterone in the heat-stressed boar may also be responsible for the lower spermatogenic activity in the testis, since the male sex hormone is necessary for the completion of spermatogenesis.

There were no seasonal differences in sperm cell motility or in the proportion of abnormal cells; this is in contrast to what has frequently been reported in studies where boars were exposed to acute heat stress in climatic chambers. Motility was generally high, and the number of morphologically abnormal spermatozoa remained within the range reported from temperate countries. These findings indicate that for these parameters of male fertility, our boars had adapted sufficiently to the level of heat stress provided by the natural tropical climate.

Fertility of the sow

In the sow, direct and indirect effects of high ambient temperatures may affect the reproductive processes which eventually culminate in the weaning of large and heavy litters. In addition to these processes, which are outlined in Figure 1, the rate of sexual maturation is of economic and genetic importance.

Age and weight at puberty. Seasonal (presumably climatic) effects on the attainment of puberty in gilts have been observed in our humid tropical climate. Gilts born before the beginning of the cool rainy season gained faster and had their first heat period when they were heavier (81 kg) and younger (224 days) than those born at the onset of the hot dry season (70 kg and 256 days, respectively). This indicates that the gilts which had most of their growth during temperatures of 28°C and above showed retarded body development, most probably due to reduced food intake, which caused a delay in sexual maturation. Compared with data from temperate countries, our gilts attained puberty two to six weeks later.

Oestrous behaviour. The mating behaviour of the sow, like that of the boar, is influenced by high ambient temperatures. During the cool season, when the mean monthly air temperatures are 25°C or below, all sows exhibit heat symptoms regularly every 20 days, and they stand quietly for the technician to inseminate them without assistance. However, with increasing temperatures during the dry season, the heat period is shortened ($r = -0.26$; $P < 0.01$) and the proportion of sows showing no heat symptoms at all (temporary anoestrus or silent heat) increases ($r = +0.43$; $P < 0.05$) by 4 percent for each degree rise in temperature (Figure 3). These results indicate that oestrous behaviour is completely suppressed at temperatures above 35°C. However, the shortened heat period may remain undetected even at lower temperatures within the range normally experienced in tropical countries (25 to 35°C), and consequently the farrowing interval may be unduly extended if heat detection is not carried out thoroughly twice a day with the assistance of a vasectomized or intact boar. The reduced sexual interest in the female during heat stress, which parallels that of the male under similar conditions, may be the

Artificial insemination can be carried out by a single technician when the sow is in standing heat

direct result of a reduction in oestrogen secretion, as suggested by the reduced activity in the oviduct which we observed in heat-stressed oestrous sows, or it may be mediated through a reduction in thyroid activity or a stimulation of the adrenal gland in response to stress. It is also possible that climatic stress adversely affects the male-female relationship of the social stimuli referred to in Figure 1, as well as the intensity of the various sensory stimuli and their receptivity, which are so important in the normal sexual behaviour of pigs. Apparently, the negative effects of high ambient temperatures are effective through the central control system, the hypothalamus and the pituitary gland. We have observed a positive relationship between ambient temperature and the required dose of synthetic steroid combinations that are administered to induce heat and ovulation in anoestrous sows, and these "reproductive cycle starters" appear to act centrally.

Structure and function of the female reproductive tract. There is no evidence that high ambient temperatures have a direct effect on ovulation rate. Even extremely heat-stressed gilts ovulated 15 to 18 eggs, provided the nutrient density of the ration was adequate to compensate for the reduced feed intake. Feeding rations containing 14 percent crude protein (levels considered adequate in temperate countries) resulted in the maturation and release of 13 ova, whereas with 31 percent crude protein the number of ova increased to 17, and this compares favourably with the results obtained in cooler climates. Similarly, our studies under field conditions failed to confirm the climatic chamber effects of high temperatures on early embryonic mortality. It is possible that our pigs reared in a tropical environment for several generations are better adapted to high temperatures than those transferred from a temperate climate into a climatic chamber where heat stress is sudden and acute.

The dependence of the structure and function of the female genital tract, the oviduct, the uterus and the vagina on seasonally varying climatic changes is apparently related to the nature of the dominating hormone. Oestrogen-dependent activities such as the development of the epithelial cells in the oviduct are depressed during the hot season,

while parameters with maximal activity during the luteal phase are not. In view of the normal ovulation, fertilization and implantation rates found in our studies, the effects of high ambient temperatures on the structure and function of the female reproductive tract may not be important economically, even if they exist.

Pregnancy and lactation. While the reproductive processes during the early stages of pregnancy are not significantly affected by the temperatures normally experienced in the tropical regions, the combined effects of high ambient temperatures during the hot season and high metabolic heat production during the terminal stages of gestation may offset the heat balance of the sow to such an extent that several of the piglets are born dead. Since metabolic heat production is a function of the intrauterine litter weight, the percentage of stillborn piglets increases with increasing litter size (see table). Sows may even die from heat stroke if the end of pregnancy coincides with the hottest month of the year. Our experiences have shown that the heat load of pregnant sows can be alleviated considerably if simple wallows are provided.

A high degree of heat stress during the second half of pregnancy, whether endogenous (metabolic) or exogenous (climatic) in origin, is known to affect the development of the mammary gland and, according to our observations, the positive balance of nutrients during pregnancy, which are later lacking during lactation. Furthermore, the effects of heat stress on feed intake and on the thyroid, as well as on other endocrine glands of importance to milk synthesis after parturition, suggest an impairment of milk production in tropical climates due to a lack of nutrients. The limited milk production data from the Philippines and from our own breeding herd have shown that yields are only half those reported from temperate countries, and consequently our preweaning growth rate is much lower than that in temperate countries.

Sow fertility at the University of Ibadan, Nigeria

Fertility trait		Pig breeding herd (1967-69)		Experimental herd (1975)
		Large White	Landrace	Crossbreds
Litters analysed		289	167	26
Farrowing interval	*days*	176	177	[2] 180
Litters per sow per year		2.1	2.1	[2] 2
Piglets born alive per litter		8.9	9.2	9.73 ± 0.09
Piglets born dead per litter	%	4.5	7.5	13.96 ± 0.50
Piglets weaned [1] per litter		7.0	7.2	8.42 ± 0.10
Piglet mortality till weaning	%	21.4	22.2	13.31 ± 0.69
Litter weight at birth	*kg*	11	13	14.99 ± 0.15
Litter weight at weaning [1]	*kg*	42	44	55.00 ± 0.49
Piglets reared per sow per year		14	15	16.84
Weaning weight per sow per year	*kg*	86	91	110.00

[1] Weaning was at 5 weeks of age. — [2] In the experimental herd batch-farrowing was practised, using two groups of sows, each farrowing twice a year.

The table shows certain important parameters of sow performance in a tropical country. Given good feeding and management, high conception rates permit the production of two litters from each sow per year, with a total of 23 piglets born and 16 to 18 weaned, but with a low weaning weight.

Conclusion

At present the numbers of stillborn piglets and inadequate preweaning growth rates require priority attention if the over-all reproductive efficiency in tropical pig production is to be improved. Studies should be conducted on the relative practicability, effectiveness and economic feasibility of devices which might facilitate behavioural and mechanical heat loss during late pregnancy and lactation.

The feeding of pregnant and lactating sows, with particular reference to the relationship between feed intake, nutrient density and environmental temperature, the quantitative and qualitative aspects of milk production, the nursing behaviour of the sow and the suckling behaviour and nutrient utilization of the piglets need to be studied — not in the climatic chamber, but in a natural tropical climate.

Other adverse effects of tropical conditions on various reproductive parameters can be avoided by good management, particularly the supply of rations with higher nutrient densities than those recommended for temperate countries, by maintaining hygienic conditions, by careful observation of the breeding stock, and by protection against unnecessary heat stress. Only at higher general levels of reproductive management, including the widespread use of artificial insemination, would climatic effects on other reproductive processes such as spermatogenesis become economically important.

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Current situation and prospects for animal feeds and meat *

COARSE GRAINS

Production of coarse grains expanded in 1975, allowing a resumed growth in consumption, an increase in trade, and expectations of a build-up of stocks. The exception has been the U.S.S.R., where poor crops disrupted growth in feedgrain production and could not be fully compensated for by imports. The situation has eased during recent months as the recovery in feeding did not accelerate as rapidly as expected earlier, and shipments to the U.S.S.R fell slightly below forecast levels. Among individual grains, maize production increased by 30 million tons to 324 million tons and millet and sorghum by 7 million tons to 111.3 million tons, while oats remained near 50 million tons and barley declined by 16 million tons to 154 million tons. End-of-season stocks are expected to increase by 3 million tons to 47 million tons, but still represent only 9 percent of consumption.[1] Stocks remain at low levels, and while prices have remained sensitive to any anticipated changes in production and trade, they have shown a tendency to decline.

On the basis of 1976 crops already harvested, intentions of producers and weather conditions in areas where crops are now planted, FAO estimates that 1976 coarse grain production may expand to slightly over 700 million tons, a level which would marginally exceed the long-term trend projected output. The expected production increase will, of course, depend upon the prevalence of normal weather conditions for the remainder of the season. Should this level of production be attained, it will allow for a continued recovery of livestock feeding in 1976/77 (July-June) in the countries that suffered a setback in 1973/74 and 1974/75, and for resumed growth in the U.S.S.R. and parts of eastern Europe.

Consumption of feedgrains is expected to expand in the United States, the European Economic Community (EEC) and Japan, which together with the U.S.S.R. represent major markets. Apart from the expected recovery in developed countries, where GNP in real terms could grow by 5 percent in 1976, the feed/livestock price ratios are becoming more attractive for grain feeding. Within the EEC, consumption patterns may shift slightly among grains as new pricing policies make lower quality domestic wheat more competitive. With the larger crops that are expected in 1976, world production as presently forecast would be sufficient to cover consumption. Trade in 1976/77 may decline from the record 1975/76 levels to near the volume of the two previous years. Stocks may be increased, but any changes must be considered highly tentative at this early date because of uncertainties regarding production, consumption and trade. The same applies to prices, which remain sensitive to fluctuations in production and demand, and among grains. While the general easing of prices might be expected to continue in the immediate future, any setback to production in even one major producing region could bring an upward pressure on prices in international markets.

OILCAKES AND MEALS

The availability of oil meal protein in the 1975/76 season is at record levels, and even with strengthening demand consumption is not likely to absorb supplies from current output. Stocks (which were already high at the start of the season) will continue to grow, particularly those of soybean. International market prices remain relatively low.

Output from current crops is expected to reach the record level of 33.2 million tons (protein equivalent), 12 percent more than in 1975 and more than 1 million tons above that suggested by an extrapolation of recent trends. Export supplies are plentiful; exporters' stocks stood at nearly 3 million tons at the beginning of the season. Output may even be somewhat higher should Latin American harvests now under way (in particular the Brazilian soybean crop currently estimated at 11.5 million tons) exceed present forecasts. Fishmeal production in Peru recommenced in late March and export shipments have started again, but prospects for the year as a whole remain very uncertain.

Demand for feed protein has already shown a strong recovery from the depressed levels of late 1974 and early 1975. This is mainly connected with the beginning of an upturn in economic activity, which has already begun in the United States and is widely expected to be followed in other developed countries, although both its timing and strength are still uncertain. The fact that prices of oil meal protein remain relatively low, both historically (i.e. when inflation is taken into account) and in comparison with competing feedgrains, is also leading to higher consumption levels. Further strengthening of demand will depend not only on the level of economic activity, as reflected in demand for livestock products, but also on whether the feeding of concentrates to livestock is sufficiently profitable and whether the price relationship between grains and oil meal protein remains favourable to the relatively high use of protein.

Thus, although the increases in total consumption will be substantial, it seems that even at current prices demand will not reach the high levels that would be necessary for output from current production to be fully absorbed. Stocks, particularly of soybean in the United States and Brazil, are expected to rise further.

Very preliminary forecasts of crops in 1976/77 suggest slightly lower out-

* As of 20 May 1976

[1] Excluding changes in China and the U.S.S.R., for which information is not available.

put, mainly due to the likelihood of a 10 percent decrease in soybean area in the United States. However, with large stocks total supplies should be adequate.

MEAT

Marked cyclical downturns in domestic beef supplies and an upswing in pigmeat and poultry meat production are expected during 1976 in most of the western European countries and in North America. The changes are likely to be less marked in western Europe. Beef production potential remains high in most of the Southern Hemisphere exporting countries and production is expected to show another substantial increase in 1976. If past cyclical patterns persist, 1977 could mark the peak of the production cycles in the main South American exporting countries. In the U.S.S.R. the shortfall in feedgrain production did not apparently cause a reduction in cattle numbers, which were reported to be about 2 percent higher at the beginning of 1976 than a year earlier. Cattle numbers decreased in most eastern European countries. The combined output of beef and veal in eastern Europe and the U.S.S.R. is, however, expected to rise by 1 to 2 percent in the current year. In contrast to most of the western European countries, the pig cycles in eastern Europe are expected to contract in 1976 and pigmeat production is forecast to remain 2 to 3 percent below the 1975 volume. There will be a major setback in pigmeat output in the U.S.S.R.; a 15 percent fall from 1975 is now expected.

According to most recent global estimates, world meat production continued to rise in 1975, but the increase was small. World output of the four main meat categories was 116 million tons and was only 1.5 percent higher than in 1974. In fact, it remained below the volume that could have been expected on the basis of longer term trends. Most of the increase was in beef and veal production in the developed countries. Pigmeat production declined sharply in western Europe and North America, causing a 2 percent drop in world output. An increase in production of mutton, lamb and poultry meat reflected expansion in the developing and centrally planned countries.

The trade forecasts shown in the table indicate a substantial increase in the net imports of western European countries, Canada, the United States and Japan. However, there is considerable uncertainty concerning some of the forecasts, particularly that of the EEC. The Community still has very large stocks of beef from market intervention purchases, and economic difficulties continue to weaken demand. The U.S.S.R. will continue to import substantial quantities of meat, but its purchases in a rising world market could fall well below those of the past two years.

World gross exports of fresh, chilled and frozen meat rose by about 12 percent in 1975 to reach 5.60 million tons. The largest absolute increase was in exports of beef and veal, which rose from 2.10 to 2.50 million tons. The net imports of western European countries, Canada, the United States and Japan increased by about 7 percent, almost entirely because of the rise in North American imports. The EEC's net imports remained very low and amounted to little more than a tenth of the net imports obtained two years earlier.

The rise in import demand has been reflected in increases in international prices. For instance, the price of Australian manufacturing type beef has been rising since late last year, and after some setbacks it was about 50 percent above 1975 levels at the end of April. It should be noted, however, that the recovery was made from an unprecedented slump. The present supply and demand outlook indicates strength in the world meat markets generally and a considerable improvement in the beef sector.

Net imports of beef and veal into selected major importing countries, by region, 1973-76 [1]

	1973	1974	1975	1976
		Thousand metric tons		
North America [2]	937.0	776.0	852.3	932.7
EEC	720.0	88.0	77.0	250.0
Others [3]	367.6	162.6	170.5	250.7
Total	2 024.6	1 026.6	1 099.8	1 433.4

SOURCE: Intergovernmental Group on Meat: Replies to annual production and trade questionnaire. Secretariat estimates for Greece, Israel, Japan, Spain and Portugal.
[1] In carcass weight, excluding meat equivalent of live animals. — [2] United States and Canada. — Greece, Israel, Japan, Portugal, Spain, Sweden and Switzerland. In product weight.

First Expert Consultation on Research on Trypanotolerance and the Breeding of Trypanotolerant Cattle

The United Nations World Food Conference that met in Rome in November 1974 recognized that the control of animal trypanosomiasis in Africa would open up vast areas of land for animal and crop production. It therefore recommended that FAO launch a long-term programme for the control of animal trypanosomiasis in Africa. This programme is now active with a small Coordinating Unit in FAO Headquarters cooperating with the governments of the countries concerned and with interested international and national organizations.

In the drier savanna areas aerial spraying of insecticides against the vector tsetse fly appears at present to be the most effective and economical method for controlling trypanosomiasis. However, in the moist savanna and gallery forest areas the ground cover is too thick for aerial spraying to be effective. The western part of the zone already has a considerable population of cattle with a low susceptibility to trypanosomiasis. Until some method of vaccination is developed, it appears that the rearing of these trypanotolerant cattle and their extension to the central part of this zone are the best prospect for exploiting it as cattle country. The presence of these cattle has long been known and intermittent studies have been made on them, but they have never been adequately or systematically investigated.

At a consultation on the FAO Programme for the Control of African Animal Trypanosomiasis held in Accra, Ghana from 2 to 4 December 1975, it was recommended that FAO sponsor research on trypanotolerance in cooperation with other international organizations, and assist trypanotolerant cattle breeding programmes. The First Expert Consultation on Research on Trypanotolerance and the Breeding of Trypanotolerant Cattle was accordingly held in Rome from 16 to 19 March 1976 in order to review present knowledge of the situation and make proposals for coordinated research and development programmes. The Consultation was attended by thirteen participants from Australia, Belgium, France, Nigeria, Senegal, the United Kingdom and the United States, and by representatives from the International Laboratory for Research on Animal Diseases, the International Livestock Centre for Africa and the International Office of Epizootics.

The Consultation was opened by D.R.F. Bommer, Assistant Director-General in charge of the FAO Agriculture Department, who welcomed the partici-

pants on behalf of the Director-General. During the course of the meeting the Director-General sent a message to say that he was personally deeply interested in the Programme for the Control of African Animal Trypanosomiasis and would recommend that it receive the budget increase requested.

Eleven working papers were presented and discussed. These papers and the discussion of them covered the present state of knowledge on the origin, characteristics, distribution and breeding of trypanotolerant breeds of cattle, with some mention of other species; the biological basis and mechanism of trypanotolerance, including immunological, physiological, nutritional, biochemical, zootechnical and genetic factors which influence it; the epizootiology and pathology of trypanosomiasis in trypanotolerant animals; research which is at present being undertaken in these fields; and current programmes for the genetic improvement of trypanotolerant breeds and for the expansion of their production in traditional farming systems and on industrial-type cattle-breeding establishments, both in their countries of origin and in countries of similar climate where tsetse infestation has impeded the development of livestock husbandry.

The recommendations included many suggestions for further research on the biological basis of tolerance and on methods to increase it by drugs (chemotherapy or chemoprophylaxis) or by improvements in the environment (feeding, management and control of other parasites and diseases). Genetic selection programmes designed to improve the productivity of the animals while maintaining or improving trypanotolerance were outlined.

It was repeatedly emphasized that there should be cooperation between organizations and countries, and that there should be standardization of sampling and analytical methods. Above all, a standard criterion for measuring trypanotolerance is urgently needed so that results from different regions can be directly compared.

Finally, the importance of comparing the economy of production of different breeds and crosses under various systems of management was emphasized. For instance, would it be better to use a more productive but trypanosome-sensitive breed and protect it by chemoprophylaxis, or to exploit a resistant but less productive breed?

The next consultation was scheduled for 1978.

World Meat Congress

This Congress will be held in Buenos Aires, Argentina from 3 to 6 August 1976. The agenda covers livestock production, industry and technology, marketing, animal health and world meat policy.

The present situation and future trends in livestock production will be considered in relation to the effects of the energy crisis and the relations between cereal and meat prices. Technological innovations and the new cost of mechanization, fertilizers and pesticides will be discussed in the context of medium- and long-term demand for meat.

The role of the meat industry, the extent to which it has been influenced by technical innovations, the investments it has undertaken and the impact of modern sanitary regulations will be the main subjects in the industry and technology part of the agenda.

Marketing specialists will analyse world trade in meat in relation to new systems and consumer requirements.

With regard to animal health, consideration will be given to the incidence of livestock diseases in international meat trade, particularly foot-and-mouth disease, brucellosis and tuberculosis, and to current systems of importation.

World meat policy will be discussed in the context of whether the meat sector will expand in the future and whether a more efficient world utilization of productive resources can be achieved by more adequate policies.

The Congress is scheduled to coincide with the Palermo International Cattle Show in Buenos Aires, which will be inaugurated on 31 July. An auction sale of the champions at the show will be held on 2 August.

A programme of visits to meat packing houses, experimental stations of the National Institute of Agricultural Technology in the pampa, semi-arid and tropical regions, the Technological Meat Centre and the Research Institute on Foot-and-Mouth Disease is planned. There will also be a presentation of experimental work on the structure and economic output of steers, an industrial exhibition on meat packing and a philatelic and medal show on cattle raising.

The official languages of the Congress will be Spanish, English and French. Further information may be obtained from the Secretariat, CENI S.A., Av. R.S. Peña 1110, 2° piso, 1035 Buenos Aires, Argentina.

Ninth International Congress on Diseases of Cattle

This Congress, organized by the French Society for Buiatrics under the auspices of the World Association for Buiatrics, will take place in the Centre international de Paris from 6 to 9 September 1976. The scientific programme consists of more than 200 reports by scientists and veterinary practitioners within the following main themes:

- **Practical surgery in the bovine.** Modern techniques for operations on the digestive apparatus, the genital organs and the limbs.

- **Diseases of the young bovine.** In the newborn — the main infectious and nutritional diseases, their causes, epidemiology and control. In large industrial units of production — diseases of the digestive and respiratory systems, their diagnosis and treatment.

- **Clinical diagnostics.** On an individual basis — diagnostic methods and complementary means for the confirmation of correct diagnoses. On a herd basis — contributions dealing with the numerous possibilities of investigating blood samples of dairy and beef cattle with the aid of biochemical techniques.

- **Management of large unit production.** Fattening — prophylactic schemes including medical prophylaxis and veterinary regulations. Milk production — aspects of disease under herd conditions, particularly the control of infertility, mastitis and metritis.

- **Free reports.** New research findings and techniques as related to metabolic diseases, atypical lung diseases and certain parasitic diseases.

Each main theme will be introduced by a rapporteur of international standing and communications on the subject will be summarized for presentation and discussion to facilitate information to the participants.

Simultaneous translation will be available in several languages in each conference room.

Parallel to the scientific programme, various social events with visits in Paris or to the outskirts of the city will be organized for the wives of the Congress participants.

After the Congress three alternative programmes will be organized. These will combine professional and tourist interests, and will include visits to breeding stations and veterinary research centres in areas of varied livestock production.

The attendance fee is F700 payable before 15 May; late fees will be higher. For hotel bookings, subscriptions and further information, application should be made to the Secretary-General of the Congress: Dr. J. Ferrand, 9e Congrès international sur les maladies du bétail, 28 rue de Petits Hôtels, 75010 Paris, France.

Animal agriculture: the biology of domestic animals and their use by man

Edited by H.H. Cole and Magnar Ronning, University of California. Freeman and Company, 1974. 788 pages, including numerous illustrations and tables. Price: US$ 15.00.

This book consists of 49 articles on specialized subjects of animal production by prominent scientific research workers and teachers, of whom 46 are from the United States, one from Australia, one from Canada and one from the United Kingdom. It provides, in a very broad frame, a concise and excellent description of the scientific basis of the biology of domestic animals and the development of animal husbandry practices. Although the main emphasis is on the livestock industry in the United States, there is a great deal of discussion on how different factors of climate, physiology and nutrition, genetics, sociology and economics have led to characteristic situations and developments all over the world.

The opening section on the scope and future of animal production is concerned with the origins of domestication and with the role of animals (in symbiosis with plants) in support of man. Three sections follow on (*a*) animal products (including meat, milk and milk products, fibre, eggs and work), (*b*) animal species, breeds, strains and hybrids for the production of such products and (*c*) genetic fundamentals and breeding methods for the improvement of specific performance traits. One article considers the possibilities of using wild animals for human food. The physiological functions and their regulation, and the essentials of animal nutrition, including feed evaluation, metabolic conversions and nutrient requirements, are dealt with in two further sections. The livestock management section parallels that for the production of livestock products, and includes an article on disease. The next concludes with a series of articles on classification of various animal products, and one on world marketing.

The authors have addressed this book in particular to students without an extensive background in biology so that it may serve for introductory courses in animal science and veterinary medicine, and also as a reference work for the libraries of professionals. Because of its introduction to a very wide spectrum of the science of biology and to the management of animals, it should also be valuable for the continuing education of biology students and for everyone interested in the animal industry. The fact that much of the information is on the United States does not limit its usefulness for other regions.

L.M.

Veterinary Parasitology

An international scientific journal. Elsevier Scientific Publishing Company, Amsterdam. Quarterly. Price: Hfl 100 (US$ 42.25) per volume (4 issues).

The first issue of *Veterinary Parasitology*, a new quarterly international scientific journal, appeared in June 1975. It is designed to publish articles of the highest quality dealing with all aspects of disease prevention, pathology, treatment, epidemiology, and control of parasitism in animals of veterinary importance. Articles dealing with the taxonomy of parasites do not fall within the scope of the journal. There will be occasional reviews and editorials, as well as a section on news items and announcements.

Veterinary Parasitology is edited by S.M. Gaafar of Purdue University, who is supported by an editorial advisory board of 35 eminent parasitologists from all over the world. If the quality and variety of articles found in the first issue can be maintained, this journal will become an indispensable addition to every parasitology library.

R.A.B.

Annuaires 1975-76

Institut national de la recherche agronomique, Paris (National Institute for Agricultural Research Annals 1975-76).

This new 269-page directory, with a foreword by Christian Bonnet, French Minister of Agriculture, presents in a remarkable and attractive way the structure and mission of France's foremost institution of agricultural research, which now has 7 000 workers distributed in 300 units located in 23 scientific departments and 16 research centres.

In the introduction the Director-General Raymond Février presents the general outline of the new policy of the Institute. Jacques Poly then summarizes the Institute's objectives of research for the Seventh Plan, of which the main goal is to contribute to an expanding modern agriculture.

This edition is more than a simple directory, since in addition to providing information on the location and size of each of the basic units of the Institute, listed by departments, it also presents its research programme.

M.C.

Hannah Research Institute Report 1975

The Hannah Research Institute, Glasgow.

After an introductory report by J.A.F. Rook, Director of the Institute, a survey is provided of the research programmes in progress in the Institute's four departments: Applied Studies, Biochemistry, Chemistry and Physiology. A wide range of activities is covered, from milk production from grass to various milk products. Abstracts of publications printed during the year are also provided. There are extensive review articles on mastitis, silage and milk powder.

M.C.

Intensive beef production

T.R. PRESTON and M.B. WILLIS. Pergamon Press, Oxford, New York, Toronto, Sydney, Paris, Braunschweig. 1974. Second edition. 567 pages, numerous tables and references, 15 plates. Price: US$ 20.00 hard cover; $15.00 flexicover.

This is the second edition of a book that was well received when it was first published in 1970. This new edition includes extensive revisions of the chapters dealing with calf rearing and sugarcane, and incorporates many important recent developments in these fields.

The authors have defined intensive beef production as "the growing and/or feeding of cattle under conditions of confinement in which all feed is carried to the animals." They have therefore worked on the premise that beef production must be viewed and organized like any other factory operation. The four parts of this publication thus deal with "the product," "the inputs," "the production" and "the future." This is an interesting and comprehensive way of dealing with most aspects of beef cattle production. Especially valuable is the fourth part, which considers current gaps in knowledge and suggests future lines of investigation. While other textbooks on the subject normally deal with the principles and techniques of beef production, this book reviews recent advances in the field and helps to identify future trends, especially in the context of research needs in the different disciplines.

There is an exhaustive collection of references, most of them from English publications or from translations into English. The tables contain fairly recent data, but there is scope for revision and updating in a third edition of the book. The plates used to illustrate the book might also be more critically selected so that they support the whole of the text and are not just used as expensive fillers.

As population pressure and land availability will favour the need for intensive beef production, this book is a valuable guide for all those concerned with the manifold facets of producing more beef in less time. The special attention this book gives to conditions in developing countries facilitates its use in parts of the world where intensive beef production has not yet been implemented on a large scale.

B.M.H.

Digestion and metabolism in the ruminant

Edited by I.W. MCDONALD and A.C. WARNER. Proceedings of the Fourth International Symposium on Ruminant Physiology. The University of New England Publishing Unit, Armidale, N.S.W. 2351, Australia, 1975. 602 pages, numerous figures, tables and references. Price: A$ 22.50.

This outstanding publication brings together the 40 papers presented at the Fourth International Symposium on Ruminant Physiology held at the University of Sydney, Australia, from 19 to 23 August 1974.

The symposium reviewed the fundamental aspects of digestive physiology and metabolism in ruminants and provided a resumé of current scientific findings in these fields.

The first chapter, comprising four papers, deals with the development of ruminal function: i.e. development of the foetal ruminant, physiology of suckling and nutrition in the preruminant calf, the reticular groove mechanism, and developmental changes of sugar and amino acid transport.

The second chapter, containing five papers, examines the structure and functions of different parts of the alimentary tract, giving particular emphasis to the reticulorumen, the omasum, and abomasum motility and its reflex control. One paper is devoted to the growth and metabolism of the ruminal epithelium in relation to feed intake.

Studies of the microflora and microfauna of the rumen and their interactions, their relation to the composition of the diet and the end products of fermentation, are presented in the third chapter.

Inorganic metabolism (especially Ca and S) and the role of the omasum in absorption and secretion of water and electrolytes are set out in four papers in Chapter 4.

The fifth chapter is devoted to recent techniques used in the study of digestion, absorption and utilization of nutrients (including re-entrant canulae and markers), the estimation of intake and utilization of nutrients by the grazing animal, and the control of feed intake in ruminants. In addition, this chapter and two later ones present 11 papers dealing with the metabolism of carbohydrates, nitrogen and lipids and their regulation. Considerable attention is given to nitrogen metabolism, with emphasis placed on the value of nitrogenous compounds entering the intestine (i.e. to aspects of protection of dietary proteins and microbial synthesis).

The last chapter discusses some factors affecting ruminant production, e.g. bloat and its relationship to legumes and feed lot regimes, and toxic substances.

The symposium on which this publication is based shows how even the more sophisticated analyses of basic mechanisms and better understanding of them can facilitate the implementation of new feeding techniques and the improvement of cattle productivity.

Orders for the publication should be sent to the Supply Officer, University of New England, Armidale, N.S.W. 2351, Australia.

M.C.

An assessment of the eradication of bovine brucellosis in England and Wales

M.E. HUGH-JONES, P.R. ELLIS and M.R. FELTON. University of Reading, Department of Agriculture and Horticulture, 1975. Study No. 19. (Mimeo). Unpriced.

As stated in the introduction, there are few economic studies of animal disease and even fewer of disease control and eradication schemes at a national level. This publication is an economic study of the strategies for eradication of brucellosis in England and Wales based on an analysis of previous and current programmes.

Although the conclusions and recommendations presented can only be applied to the particular circumstances prevailing in the region under consideration, this publication can be valuable to readers from other regions because it illustrates an approach which should be more widely applied, especially in the developing countries, for the allocation of available resources to the economically most promising disease eradication or control programmes and for the establishment of the most suitable strategies. It demonstrates the importance of using an interdisciplinary approach combining agricultural economics, epidemiology and animal husbandry to devise ways to eradicate disease.

C.A.H.

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Yugoslavia	Jugoslovenska Knjiga, Terazije 27/11, Belgrade; Cankarjeva Zalozba, P.O. Box 201-IV, Ljubljana.
Other countries	Requests from countries where sales agents have not yet been appointed may be sent to: Distribution and Sales Section, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.
Autres pays	Les commandes ou les demandes de renseignements émanant de pays pour lesquels des agents ou des dépositaires n'ont pas encore été désignés peuvent être adressées à: Section distribution et ventes, Organisation des Nations Unies pour l'alimentation et l'agriculture, Via delle Terme di Caracalla, 00100 Rome, Italie.
Otros países	Los pedidos procedentes de países en donde aún no han sido designados agentes distribuidores, pueden hacerse directamente a la Sección de Distribución y Venta, FAO, Via delle Terme di Caracalla, 00100 Roma, Italia.

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